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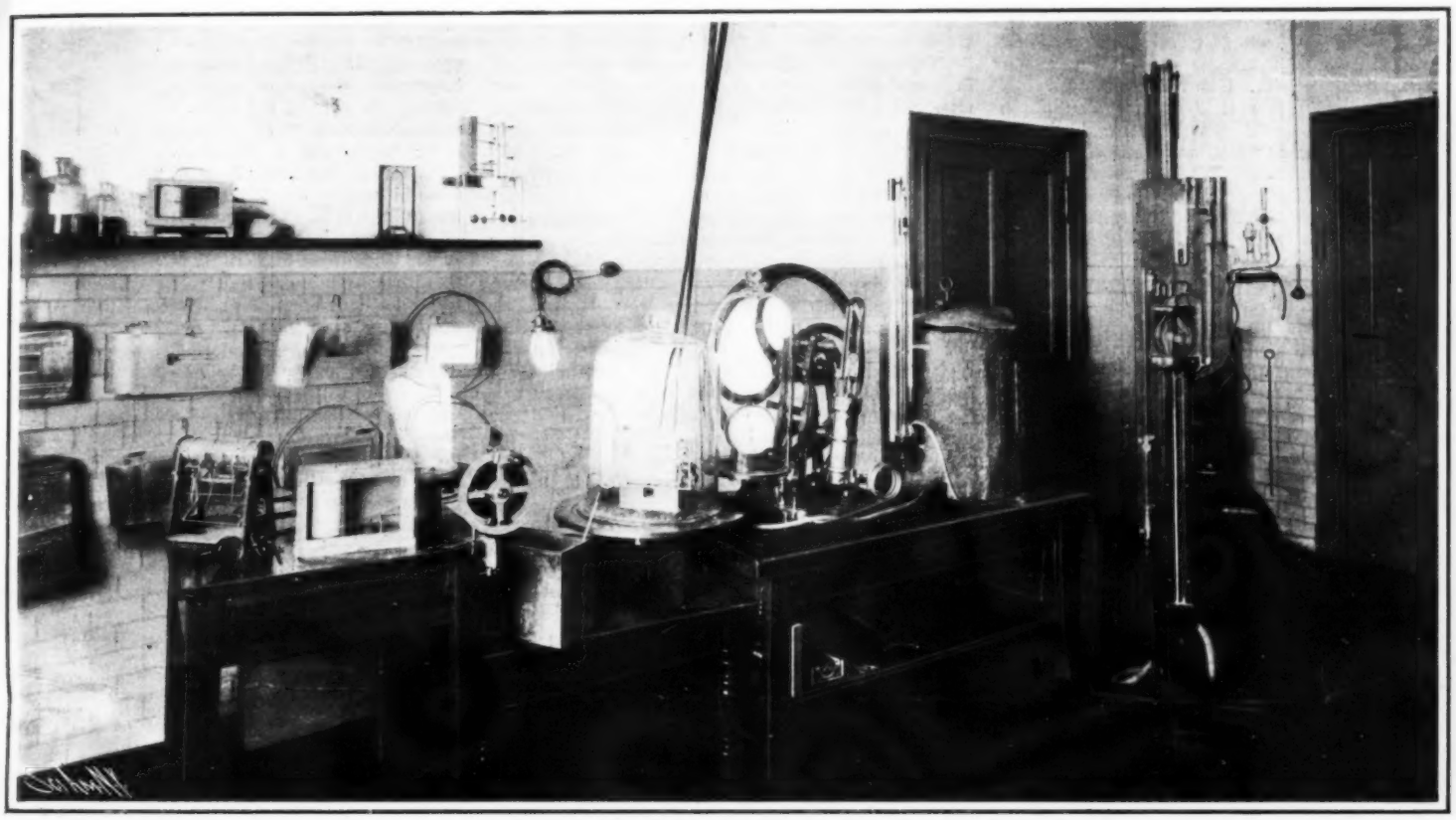
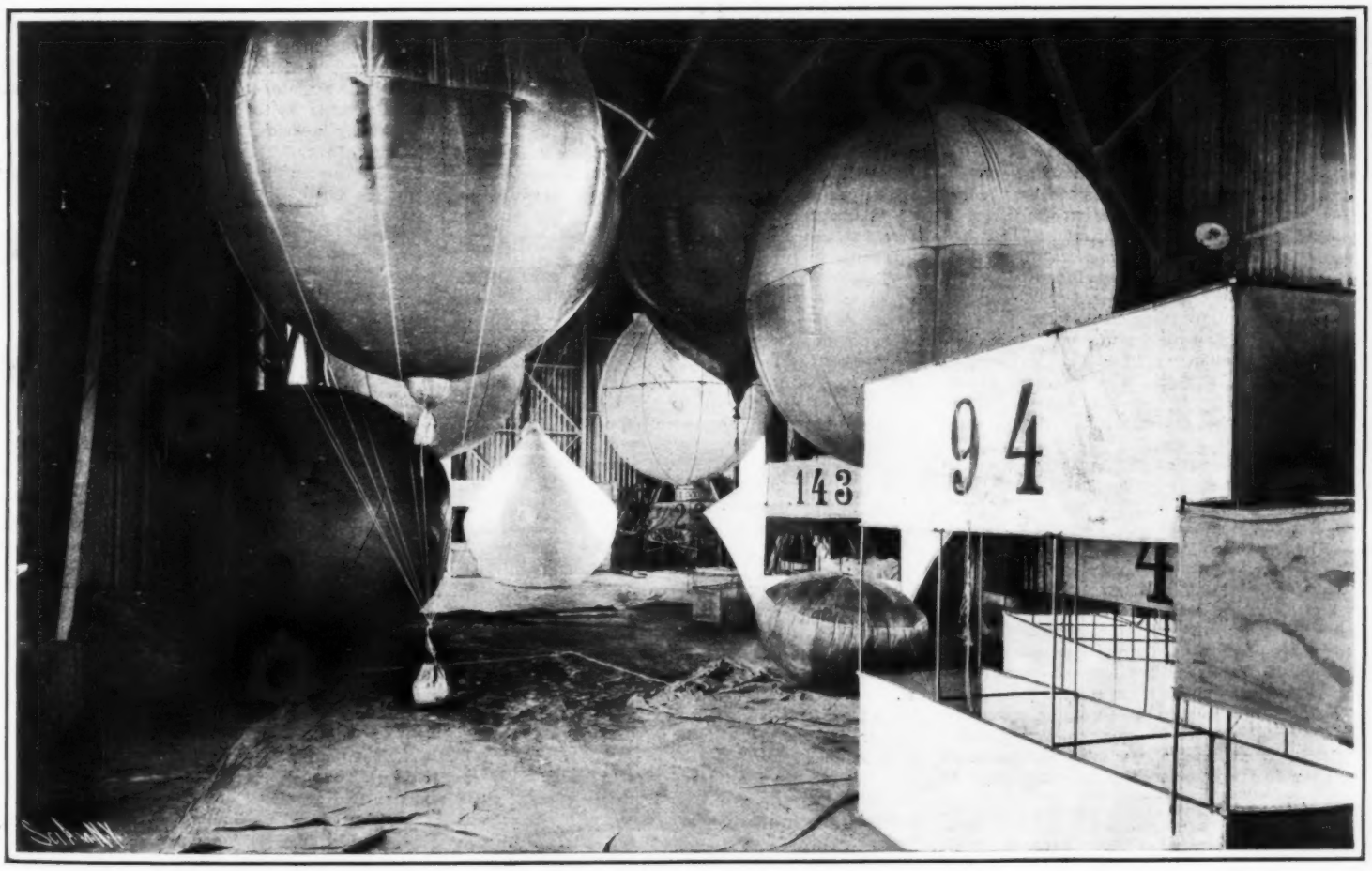


TESTING ROOM, SHOWING THE MARVIN RECORDING APPARATUS AND AIR PUMPS



INTERIOR VIEW OF THE BALLOON SHED.

AN AERONAUTICAL OBSERVATORY.—[See page 24.]

GYPSUM PLASTER AND GYPSUM PRODUCTS AS BUILDING MATERIALS.*

BY MARCO PEDROTTI.

GYPSUM is not only used as mortar in cementing stones together for structural purposes, for finishing walls and ceilings, running cornices, etc., but artificial building materials, stones, plaster boards, etc., can be made from it, that can be employed for casings, partitions, coverings, etc., and it is employed in a new system of construction, based on the use of plaster and iron. In this manner, on broken stone foundations, concrete structures are raised with an interior framework irregularly inclosed with laths and strips, and the wall then filled in with broken stone and plaster mortar. For solid ceilings I beams are employed, set at a distance of 0.6 to 1 meter apart, resting on the walls, and separately secured by means of wall-joints. Then, from square iron rods, 2 centimeters thick, a network is formed; over this net, parallel to the beams, come thin iron rods and finally wood strips. The lattice work thus formed, is filled in with paster and broken stone. For the floor, above the ceiling, rods are again laid, with strips, over which plaster is again distributed. Such a ceiling will have a thickness of about 21 centimeters, while if of wood it would be 40 centimeters thick. In the so-called honeycomb floors, the ceiling, between the traverses, is filled in with six-sided, small plaster prisms, hollow in the center and placed side by side. At first, a temporary support is constructed underneath of boards, on which are sheet-metal plates, which can readily be raised or lowered by means of a framework. Six-sided wooden prisms fit, with a pin, into the holes, and after they have been inserted, the interstices are poured full of plaster. The finished cells, open at the top, are covered with plaster slabs, on which the floor is laid. The small holes in the foundation facilitate drying out and are of great advantage in securing the platform. For filling in iron floors, hollow forms of plaster are made, as a substitute for the hollow clay forms, which are much more expensive than those of plaster.

Artificial building blocks are made in Paris of plaster, alum, and iron filings or hammer scale, from which mixture hollow tiles and chimney flues are also made. This product has the advantage of being strong and light, but labors under the demerit of becoming soft if exposed to water. It is not to be recommended for chimney linings, owing to its liability to develop fissures, in which case the tubes must be incased in masonry. Other artificial stones consist of plaster, with a small quantity of lime, alum, and glue; the mixture is colored in different ways and made up into hollow or solid stones, moldings, floor slabs, etc., or it is used, with the addition of sand, as mortar.

The principal artificial building materials, however, are plaster boards and plaster planks, with or without hollow spaces, such as are made by many firms and serve as an excellent material for partition walls, ceilings, etc.

The Rhenisch Plaster Industry Company at Heidelberg makes plaster boards or rush boards by machinery. Originally rush boards were made by winding cords over round or oval sticks, laying the device in the molding box, pouring in plaster, and after it had hardened, pulling out the cords. In recent times, however, the concern in question employs improved casting benches and reed weaving machines, by which means the greatest uniformity in the goods is insured. When employed for building barracks the rush boards are saturated with a sanitary fluid and thereby hardened and made antiseptic. The walls made from this material are first finished with thin and then with thicker "black" (schwarz) lime mortar, and finally given three coats of oil paint.

Clemm, of Hochhausen on the Neckar, makes rush board from prepared plaster and selected reed. They are from 2.5 to 12 centimeters thick, weigh 20 to 84 kilogrammes per square kilometer, are made in sizes of half a square meter, and come without any asphalt coating. They are fastened to wood with galvanized nails that are at least 3 centimeters longer than the boards are thick. The meeting edges, that are always to be set horizontal and edgewise, should never be placed in contact with each other or with wall surfaces dry, but should be previously moistened with plaster paste. The boards should be set in bond and any finish given them is best applied in pure plaster mortar. Placing the rush boards together dry, may cause cracks in the finish. For joining, plaster mixed in glue water should be used. To prevent subsequent seams and cracks, the rush boards must be solidly attached to the masonry; if no support is provided, it must be prepared, cut about 2 centimeters deep into the masonry and wash it out clean so that the plaster paste on the applied rush boards will make a good bond. After this the nailing on of the boards should be attended to.

Other hollow boards have no reinforcement of organic substance, but are made of pure, very hard plaster, and are provided internally with wide cylindrical channels. Only when they are designed to sustain heavier loads are they reinforced with wire. These boards are distinguished for durability, fireproof quality, dryness and lightness, and are indifferent conductors of heat or sound; they are furnished in thicknesses of 7, 10, and 14 centimeters, and in lengths of 1 to 1.25 meters, as well as in widths of 20, 35, and 40 centimeters; the diameter of the channels is 5.7 and 10 centimeters, and their weight per square meter, 55, 80, and 102 kilogrammes.

These hollow boards are capable of absorbing a large amount of moisture without softening or losing their solidity. Their bearing strength is very considerable; a hollow board, supported freely at each end, 14 centimeters thick and 40 centimeters wide, showed, for instance, a breaking strength of about 4,000 kilogrammes per square meter, whereas a deal, 7 centimeters thick and 20 centimeters wide, broke under a load of about 1,000 kilogrammes per square meter.

Wood fiber (rope) boards consist of wood-wool rope impregnated with water glass and imbedded longitudinally, close together in plaster paste, and are supplied in lengths of 2.5 meters, 40 centimeters broad, and 2.5 to 10 centimeters thick. Their weight per square meter varies between 15 kilogrammes (for boards 2.5 centimeters thick) and 51 kilogrammes (for boards 9 centimeters thick). The material is said to possess great strength and to be free from all tendency to shrink, split, or warp. Owing to their great porosity, wood fiber (rope) boards are poor conductors of heat and sound, are fire-resistant, can be sawed, nailed and planed and are recommended for covering ceilings, to receive the finishing coat, for floor linings, and also for floors, in which case they require covering with linoleum or a plaster coat, for roof insulation, as filling, for covering thin walls of wood or iron structures, or for roofing, in which case they require a coating of asphalt, from 1 to 1.5 centimeters thick.

Chaff-boards or slabs are hollow boards 67 centimeters long, 20 centimeters broad, and 10 to 13 centimeters thick, made of a mixture of plaster, lime, etc., on the one hand and chaff (the refuse of threshed straw), saw dust, cork dust, tan, and animal hair, which, with the addition of glue water, in specially constructed machines, is intimately mixed and cast, in metal molds, into boards (slabs). The hollow spaces (four-sided longitudinal passages) make up 25 per cent of the volume; the weight, for the cubic meter, is about 500 kilogrammes, or for tablets 10 centimeters thick 50 kilogrammes, for 13 centimeter tablets 60 to 65 kilogrammes to the square meter. The average breaking strain is placed at 25.7 kilogrammes to the square meter.

These chaff boards are dry, fire resistant, light, sound deadening, heat insulating, easily used at any season of the year, can be cut as desired with an ordinary hand saw, and meet all the hygienic requirements that can be made of a good building material. They make good insulating material and are just as well adapted for material for inter-ceilings, light walls (strut-framed walls, square-framed walls, sound-proof double partition walls) for tar and other roofs, barracks, arches, etc., but are not suited for use where they are likely to be exposed to the effects of water or damp vapors, though by impregnation they may be made impermeable to moisture. Against ascending moisture from the ground, unimpregnated chaff boards must be protected by the most careful insulation. Chaff tablets have on both sides uniform and naturally rough surfaces, to which the finish adheres admirably. The finish, to be applied of a thickness of at most 8 millimeters, is best made of pure plaster mortar. The tablets are set in tiers (bond) and previously lightly moistened on the long and short sides, with a brush, dipped in water; as a cement either pure plaster mortar, or lime mortar, with 15 to 20 volumes of plaster, may be used.

PLASTER MORTAR AND PLASTER FINISH.

The employment of plaster in the erection of stone structures, imparts to them great solidity, as was proved by the buildings dating from the thirteenth century, recently demolished. Generally speaking, however, plaster, as a building mortar, is too expensive; moreover, finely ground plaster possesses the disagreeable property of speedily setting, in which form it is unfit for use. To make a practicable mortar from plaster, we must use a plaster the grains of which are about as large as coarse building sand; a material of this nature is made from 8 parts of plaster and 5 parts of water for thick and 8 parts of plaster and 11 parts of water for thin mortar. To prevent uneven absorption of water and the formation of air bubbles, the water must be added to the plaster powder in such quantity, and with constant stirring, as will insure the most even, not too thin paste. If the plaster mortar is mixed with too much water, it will be, after hardening, porous and not as solid, because after the water evaporates its volume cannot change. If we take an insufficient quantity of water for the preparation of mortar, the mortar, it is true, will be harder, but it sets quicker and for some purposes soon becomes useless or at any rate inconvenient.

Plaster mortar must be used as soon as possible after mixing, before it begins to set; it is therefore best to mix it in small quantities and use it at once. Plaster mortar can be used at a cold temperature of 10 deg. C. without danger. It is used alone, or mixed with lime, sand or finely pulverized blast furnace slag for masonry, and because it sets quickly and soon dries is particularly adapted for arch work. For such use a mixture of 1 part of plaster and half a part of lime mortar, prepared with fine sand, has proved excellent. Much more common, however, is the employment of plaster mortar for wall and ceiling finish. For the first, a favorite mixture is 3 parts of lime, 1 part of plaster, and 4½ parts of fine white sand (plaster lime) and for ceiling finish, a mixture of 2 volumes of plaster and 1 part sand (without lime). Smooth wall and ceiling surfaces are obtained when the surface, finished in plaster and glue water, is rubbed down first with pumice stone, then with fine sandstone, then with tripoli and a felt pad, and finally with linen, also in conjunction with soap water. The polishing is effected with the aid of a woolen rag soaked in oil or wax solution.

A brilliant wall surface is also obtained with the aid of the so-called white stucco finish. After the surface has been finished in ordinary lime mortar, and the latter is perfectly dry, a mixture of finely sifted lime, with an addition of 10 per cent of fine sand or marble dust and plaster paste, is smoothly applied two or three times, on each occasion in a coat about 1 millimeter thick, with a steel rubbing float, rubbed down smooth, scoured with water and cleansed of the slime, and either left in that state, or when absolutely dry, painted or saturated with glue water and treated with a wax polish.

To attach plaster mortar to ceilings, use either a cane trellis made of loose cane stalks, tempered wire, and wire nails, in the interstices of which the finish will readily become attached, or better still, a weave, made up of parallel reeds, laid side by side, and wire, or 2½-centimeter thick laths, somewhat sprung off toward the top ("pliester" laths) nailed to the lower side of the ceiling beams 2½ centimeters apart, or thin laths ("splinter" laths) nailed over heavier laths and secured to the beams. Plaster finish cannot be applied to wet walls or ceilings, it will never dry, but is "drowned" and gradually loses its setting property.

If plaster mortar comes in contact with iron (wire, nails, screws, etc.) through the sulphuric acid remaining in the plaster, an oxidation of the metal takes place, which, while it may within certain limits be desirable, if allowed to proceed too far, will cause the complete destruction of the metal. This effect is particularly to be feared when the plaster cannot dry fast enough.

A finish made with hydraulic plaster, although on the whole excellent, firm and weatherproof, at certain points, not under the influence of frost, formed small, scaly exfoliations, which while they did not become loose spontaneously, could be readily detached. At the places where these scaly spots occurred, at a depth of about 2 to 3 millimeters, a large granule was found, as a rule a little disk, lying flat, parallel with the surface, of 3 to 6½ millimeters diameter (greatest) and 1 to 1½ millimeters thick, consisting of a reddish, green, or blackish, hard mass, fragments of carboniferous slate, in various stages of calcination. As the original material, a rather coarsely ground coating plaster, contained quite a few similar particles, it may be concluded that we were dealing with an impurity the plaster had acquired, while being burned, that originated in the coal used.

The injurious effect of the slate particles was doubtless wholly mechanical. The flat, fairly smooth foreign bodies interrupted the continuity of the plaster principally in a direction vertical to their largest extent. As, however, under the pressure exercised in

* The following articles should be read in connection with this: "Gypsum, a Much Misunderstood Material" SCIENTIFIC AMERICAN SUPPLEMENT 1590; "Industrial Applications of Gypsum," SUPPLEMENTS 1604 and 1605; "Practical Results in the Preparation of Plastic Materials," SUPPLEMENT 1610; "Gypsum and Its Utilization," SUPPLEMENT 1625; "Slaking of Plaster and Means of Retarding Its Hardening," SUPPLEMENT 1626; "Means of Retarding the Hardening of Plaster," SUPPLEMENT 1637.

spreading the finish, acting under a familiar mechanical law, they were the more nearly parallel to the surface, the closer they were to it, in the particles lying close to the surface the direction of least resistance would correspond with the normal of the finished surface, which would cause, under the influence of the almost insignificant contraction of the hardening plaster, a loosening of the cohesion that would lead to the formation of cracks and flaking off owing to the effect of the changing temperature and moisture conditions.

The co-operation of chemical factors, or a consequent water-absorbing action of the slate, which might have increased its volume, could not be considered in the case described, for as special tests demonstrated, the slate in question possessed no hydraulic properties. The re-heated slate, after digestion for hours in boiling water and remaining twenty-four hours in a moist condition, was dried in an exsiccator and found to contain but 0.09 per cent of bound water, which disproved the possibility of any bursting effect by increase in volume.

In order to compare the value of different mortars of pure plaster and plaster with various additions, Lorenz and Thiemann made the following mortars with plaster from Quedlinburg and Spermberg:

	I.	II.	III.	IV.
Calcined plaster	92	88	87	82
Uncalcined plaster.....	—	—	5	9
Slaked lime.....	4	7	4	5.5
Pure quartzose sand...	3	3	3	2
Potash alum	1	1	—	—
Wood ash.....	—	—	1	1.5

The components used, with the exception of the lime, which was added first with the water, were mixed to a mass as nearly uniform as possible and then the water stirred in. The work of stirring called for particular care, as it was necessary to make sure that no air bubbles occurred in the plaster and only the exact amount of water needed was added. The quantity of water used varied between 61 and 69 per cent, the water contained in the carbonate of lime being also taken into consideration. It is true that the plaster hardened, even when quite a large quantity of water was used, because it gradually evaporated. From this it is evident that a mortar made with an excessive proportion of water is more porous and not as hard because the volume of plaster, after the water has evaporated, is not changed. If the crystalline granular plaster, which after burning displays the original structure, is coarsely ground, the surface of the separate coarse particles hardens first, whereupon the water gradually penetrates into the interior, which is only slaked after the outer surface is set. As the slaking of the inner portion cannot be attended with any change of volume, it follows that a mortar made from coarsely ground plaster will be denser and more solid than if made from finely ground plaster. In the latter case, properly burned plaster, mixed with the right quantity of water, hardens almost immediately, whereas coarsely ground plaster does not set so that it can no longer be worked, until after about five minutes. Additions of alum and lime retard the hardening, whereas the addition of brick dust accelerates it. If with the burned plaster unburned plaster to the amount of 10 per cent is mixed, this has no influence on the hardening.

Of the above-mentioned mixtures, for the purpose of testing their solidity, cubes with a side length of 5 centimeters were made, which were then subjected to further examination. The almost simultaneous occurrence of fissures and their destruction occurred under a pressure per square centimeter and kilogramme as follows:

1. Quedlinburg plaster, without additions.....	90.70
" " mixture I.....	81.53
" " " II.....	80.26
" " " III.....	121.30
" " " IV.....	144.50
2. Spermberg plaster, without additions.....	146.50
" " mixture I.....	49.80
" " " II.....	133.06
" " " III.....	131.90
" " " IV.....	132.13
Average for both kinds, 111.16, or.....	1.11
Whereas such for ordinary bricks was.....	0.60
Whereas such for good bricks was.....	1.00
Cement mortar	1.50
Lime mortar moderate age (?).....	0.40

This shows that the strength of plaster mortar is not as small as is generally supposed. An important effect on the solidity and weather-resisting capacity of plaster is exercised by the manner of mixing and the admixtures for which sharp sand, river gravel, or pieces of hard broken stone are to be recommended.—Translated from "Der Gips und seine Verwendung."

THE PSYCHO-PHYSICAL ASPECT OF CLIMATE.

WHY ENGLISHMEN TALK ABOUT THE WEATHER.

IT is a well-established fact, proved by common and shuddering observations as by the statistics of meteorologists, that the British Isles are more liable to suffer from east and northeast winds during the spring than at any other time of the year. May is more frequently the selected time than April, while in March, despite popular notions, the cold current is likely to be from the north or northwest rather than from the northeast and east. No one will deny that the May which has just finished its course was a disappointing as well as a very trying month, and an examination of the daily charts of weather published by the Meteorological Office makes it clear that the inclement condition was due to the wretched persistency with which the atmospheric pressure remained greatest over the Icelandic and Scandinavian region and lowest over the Spanish Peninsula, France, and Germany. This distribution of pressure is exactly the reverse to that obtaining over these parts of the earth's surface during the greater portion of the year and, of course, compels the air to flow from the Arctic northeast of Europe across the British Isles. There were certainly occasions during the month when a temporary displacement of the northern anticyclone and the near proximity of cyclonic systems to our west and southwest coasts brought about winds from milder quarters, enabling the thermometer to rise to the normal and for a brief period far above it, but these leniencies were few. At the commencement of the month the wind was westerly to southwesterly, and from the 7th to the 12th there was a southerly current that brought up very warm air from the Mediterranean region and raised the shade temperature to 79 deg. F. in London and to 80 deg., even a little above it, in several parts of the home counties and in the northeast of England. There was also another short interval of warmth from the 23d to the 25th, when the thermometer rose to about 70 deg. in the southeast as well as in some districts in the north and northwest of England. The wind as it blew over the metropolitan area during this period was sometimes from the eastward, but in reality the air-current then prevailing came from a more southerly point of the compass and was only deflected into east as it arrived on this side of the Channel. These summer-like interludes were very enjoyable but they only served to render the subsequent relapse to abnormal cold the more disagreeable and the more perilous. The worst spell of cold occurred about Whitsuntide; during three days the thermometer in London and over the greater part of the country failed to rise above 51 deg., and on the fourth day only touched 52 deg. As the average temperature for the afternoon during that period of the month is about 62 deg., it will be seen that the universal complaints against the weather at the holiday period were veritably justified. In Scotland and the north of England the weather was even more consistently cold, the occasional warmth in the south only reaching those districts in a modified degree or failing to affect them altogether. But certain parts of Scotland were capriciously hot; on the 26th, for instance, the shaded thermometer at Lairg in Sutherlandshire ascended to the high point of 79 deg. Owing to the few warm spells and to the absence of any abnormal frosts the mean temperature for the month was not as a rule much below the average, but the sunshine was almost everywhere gravely deficient, while the quantity of rainfall was generally in excess over some parts of the north and northeast of Great Britain, the aggregates being more than double the average amount.

The reason why we, as a nation, invariably introduce conversation with a stranger, and not infrequently with a friend, by remarks upon the weather is, of course, that in our so variable climate the weather is actually of prime importance to our lives. We have just had placed before us an interesting pamphlet* which may be regarded in a sense as a plea for more exact talking about the weather, and as such we bring it to the notice of our readers. About three years ago we gave some account of the scheme by which Mr. W. F. Tyler, of Shanghai, proposed to make exact comparisons of climates and this pamphlet further develops his scheme. He says that in a general sense the term climate indicates the idea of varying degrees of physical comfort or discomfort resulting from the local meteorological conditions. In mild climates, among which, despite our recent experiences, he includes the climate of the British Isles, the means of describing the combined effects of local conditions is generally limited to calling the climate either "bracing" or "relaxing," as the case may be. In tropical or semi-tropical climates, such as those encountered in China, a means of describing the varying degrees of discomfort is practically non-existent. The weather may be called "muggy," but the degree of mugginess can only be denoted by various inexplicit adverbial adjuncts. There are, however, very strong grounds for suspecting that temperature and humidity are the most important of the conditions that go to make up "mugginess." These can, of course, be measured by ordinary physical methods with considerable precision, and Mr. Tyler has endeavored to show how the varying bodily sensations associated with changes in the weather may be numerically expressed. For the purpose of this investigation it appeared necessary to invent a word indicating the sensation caused by a "muggy" climate and the term selected is "hyther" (a "portmanteau" word coined from hydrothermos). The "hyther" scale has for its limits the numbers 0 and 10. Limit 10 represents the very worst day an observer remembered to have experienced in China—hot, damp, and enervating; while limit 0 represents an ideal summer day—warm, of course, but bright and bracing, so that a person suitably clothed and not exerting himself unreasonably or unseasonably suffers no discomfort from the climatic conditions. On each day of the month of August, 1902, at Shanghai, twelve individuals at noon estimated the degree of "hyther." They were all persons of normal condition, regular habits, and equable temperament. Instrumented meteorological observations for the purpose of comparing with the estimated "hyther" were obtained from the neighboring Zicawei observatory. When the estimated "hyther" numbers and also the readings of the wet-bulb thermometer were plotted on squared paper a remarkable correspondence between the respective graphic curves was apparent, and Mr. Tyler found that the relation between the "hyther" numbers (h) and the wet-bulb readings (w) was aproximately represented by the equation—

$$h = \frac{w - 66}{3}$$

Mr. Tyler reinforced his observations on the production of a sensation scale, founded on the estimations of the temperature of water by persons who dipped their hands successively into water at 43 deg. F., at 120 deg. F., and at the temperature to be estimated, but for his interesting observations in this direction we refer our readers to his record of his work. We have referred to it in connection with a brief consideration of the disagreeable May which we have just experienced because it suggests to us that the scientific study of weather is not sufficiently pursued among us. We are most of us content in our frequent allusions to the subject to employ any inaccurate terms which come into our mouths, because meteorology is not really studied by a sufficiently large number of persons to make the carelessness of our phraseology noticeable.—London Lancet.

* "The Psycho-Physical Aspect of Climate with a Theory concerning Intensities of Sensation," by W. F. Tyler, F.R. Met. Soc., Assoc. Inst. C.E. Reprinted by permission from the Journal of Tropical Medicine and Hygiene, April 15, 1907. London: John Bale, Sons, and Danielsson, Limited. 45 pages and four folding plates.

LEAD IN ICE CREAM.

BALDONI (Riforma Med.) finds considerable amounts of lead in ice cream, fruit ices, etc., as sold in Rome. He attributes many of the disturbances of digestion occurring during the summer when ice cream, fruit ices, sorbets, etc., are consumed in larger quantities to the lead contained in these articles. The linings of the receptacles in which ice cream is made often consist of an alloy of tin and lead. The ingredients of ice cream dissolve this, but in addition to this, in turning the mass in the freezer a certain amount of the lining of the vessel is rubbed into the cream. This was proved conclusively by the writer, who found that particles of tin and copper were precipitated at the bottom of glass vessels in which he melted ice cream. On filtering the liquids these articles also were found on the filter. He destroyed the organic portions of the cream by means of fuming nitric acid and by electrolysis, and recovered the lead.

Flash Light Powder for Instantaneous Photographic Exposures.—Small cylindrical cartridge cases, made from the thinnest cardboard, are filled with the flash-light powder, consisting of 13.8 parts of anhydrous perchlorate of potash and 9.6 parts of pulverized magnesium, intimately mixed, by means of a quill; on this is placed a pinch of combustion salt—1 part of lactic sugar and 3 parts of chlorate of potash, mixed—and over this a thin covering of guncotton, which projects on one side, outside of the lid of tissue paper that covers the cylinder. The cartridges are not explosive and can be set off in the hand.

THREE LARGE MALLET COMPOUND LOCOMOTIVES.

A DESCRIPTION OF THE BIGGEST ENGINES EVER BUILT FOR A RAILWAY.

THE three articulated compound locomotives now building at the Schenectady Works of the American Locomotive Company for the Erie Railroad will be the heaviest and most powerful engines ever built,

THE LOW-PRESSURE CYLINDERS OF THE NEW LOCOMOTIVES ARE 39 INCHES IN DIAMETER BY THE SAME STROKE.

and will break all records in locomotive construction. They are of the type known as the Mallet compound, and will have sixteen driving wheels, arranged in two independent groups of eight each. The high-pressure cylinders, which are 25 inches in diameter by 28 inches stroke, drive the rear group of driving wheels, and the low-pressure cylinders, which are 39 inches in diameter by the same stroke, drive the forward group of wheels. The four rear pairs of wheels are arranged in frames which are rigidly attached to the boiler. The forward four pairs of drivers are, however, carried in frames which are not rigidly connected with the barrel of the boiler, but which are in fact a truck, swiveling radially from a center pin located just in advance of the high-pressure cylinders. The locomotive alone without tender will weigh 205 tons, and will haul on the level 320 loaded freight cars, or a train about two miles long.

In the accompanying photographs are shown the boiler and firebox foundation ring and low-pressure cylinders of these immense machines. The boiler is over 43 feet long, and the inside diameter of the largest ring is 8 feet. It is provided with 404 tubes, each 2¼ inches in diameter and 21 feet long. The water alone in the boiler will weigh 42,700 pounds. The tubes weigh 23,700 pounds. The firebox of this boiler would make a good-sized living room, since it is 10½ feet long and 9½ feet wide inside, and has a grate area of 100 square feet. The man standing at the right in the illustration of the firebox foundation ring is 6 feet 3 inches tall, which gives a good idea of the immense proportions of the ring itself.

The first example of this type of locomotive in this country was the Mallet compound built by the same company for the Baltimore & Ohio Railroad in 1904, and described in the SCIENTIFIC AMERICAN of that year. This engine astounded the locomotive world at that time by its enormous size, but these engines for the Erie Railroad will be much heavier than their predecessor. The decided success of the Baltimore & Ohio engine, however, has proved the advantages offered by this type for exceptional weight and hauling power, and justifies this still greater development of the type.

EFFECT OF DURATION OF STRESS ON STRENGTH AND STIFFNESS OF WOOD.

IT has been established that a wooden beam which for a short period will sustain safely a certain load, may break eventually if the load remains. For instance, wooden beams have been known to break after fifteen months under a constant load of but sixty per cent of that required to break them in an ordinary short test. There is but little definite and systematic knowledge of the influence of the time element on the behavior of wood under stress. This relation of the duration of the stress to the strength and stiffness of wood is now being studied by the Forest Service of the United States Department of Agriculture at its timber-testing stations at Yale and Purdue universities. The investigation should determine: The effect of a constant load on strength; the effect of impact load or sudden shock; the effect of different speeds of the testing machine used in the ordinary tests of timber under gradually increasing load; and the effect of long-continued vibration.

To determine the effect of constant load on the strength of wood, a special apparatus has been devised by which tests on a series of five beams may be carried on simultaneously. These beams are 2 by 2 inches in section and 36 inches in length, each under a different load. Their deflections and breaking points are automatically recorded upon a drum which requires thirty days for one rotation. The results of these tests extending over long periods of time may be compared with those on ordinary testing machines, and in this way safe constants, or "dead" loads, for certain timbers may be determined as to breaking strength or limited deflections. The experiments of the Forest Service show that the effects of impact and gradually applied loads are different, provided that the stress applied by either method is within the elastic limit of the piece under test. For example, a stick will bend twice as far without showing loss of elasticity under impact, or when the load is applied by a blow, as it will under the gradually increasing pressure ordinarily used in testing. The experiments are being extended to determine the relations between strength under impact and gradual loads.

Bending and compression tests to determine the effect of the speed of application of load on the strength and stiffness of wood have already been made at the Yale laboratory. The bending tests were made at speeds of deflection varying from 2.3 inches per minute to 0.0045, and required from twenty seconds to six hours for each test. The woods used were longleaf pine, red spruce, and chestnut, both soaked and kiln-dried.

From the results are obtained comparable records for difference in speeds in the application of load. A multiplication of the results of any test at any speed by the proper reduction factor, derived from these experiments, will give equivalent values at standard speed. The tests also show concretely the variation of strength due to variations of speed liable to occur during the test itself. The results plotted on cross-section paper give a remarkably even curve as an expression of the relation of strength to speed of

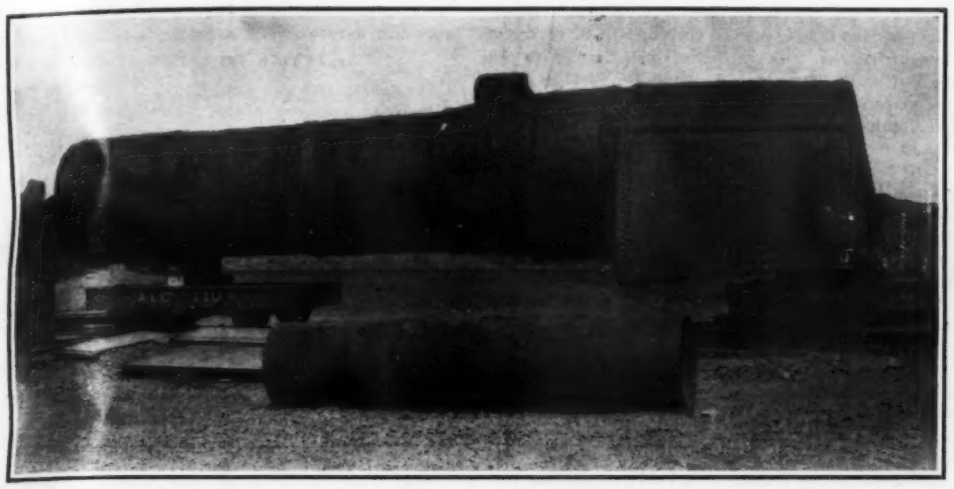
THE MAN STANDING IN THIS RING IS 6 FEET 3 INCHES TALL, AND THE RING ITSELF IS 8 FEET IN DIAMETER.

THE FORWARD FOUR PAIRS OF DRIVERS WILL BE CARRIED IN A FRAME CONSTITUTING A SWIVELING TRUCK.

THREE LARGE MALLET COMPOUND LOCOMOTIVES.

application of load, and show much greater strength at the higher speeds.

It is common belief among polemen that the continual vibrations to which telephone poles are subjected take the life out of the wood and render it brash and weak. Nothing is definitely known as to the truth or falsity of this idea. Tests will be undertaken to determine the effect of constant vibration on the strength of wood.



THE BOILER IS OVER 43 FEET LONG AND THE INSIDE DIAMETER OF THE LARGEST RING IS 8 FEET. THE WATER IN THE BOILER WILL WEIGH 42,700 POUNDS. THE TUBES WEIGH 23,700 POUNDS.

TUNNEL VENTILATION.

In a paper read by M. C. Birault upon tunnel ventilation before the Société des Ingenieurs Civils, he speaks of the method used in the Paris subway, among others. The conditions of the air supply are known in a very exact manner from the analysis of the air and temperature tests, also water vapor measurements, made by M. Albert Levy, of the Montsouris Observatory, for some years past. Air is taken in each tunnel midway between the stations at 4 o'clock P. M. each day. The Vincennes-Maillot subway station, the first to be built, is entirely underground, except the open-air station at the Bastille. As was to be foreseen, it is in the western part of the tunnel that the air is the most vitiated, due to the length of the tunnel, 4.3 miles, and also because this part has the most traffic. The quantities of carbonic acid continue to increase as we proceed from the open-air station at the Bastille in either direction. When a diminution is noticed toward the ends of the line. The atmosphere of the tunnels is always more humid than that of the outer air, and the water vapor figure varies about as the carbonic acid. As to the temperatures, they are not much influenced by the variations at the surface even when great. The action of the seasons has but little influence, and the mean temperature of the air in the tunnels is only about 3 deg. C. lower in winter than in summer. In a given day, the hourly variations of temperature follow a very regular law in all seasons. We observe a minimum at 4 o'clock A. M. and a maximum at 8 P. M. The thermometer falls in a noticeable manner from 12:30 A. M., when the traffic ceases and the station doors are opened in order to aerate the tunnel. In one section a series of observations were made. In summer the highest temperature is 21 deg. C. and the lowest is 22.5 deg. In winter we find 20 and 17.3 deg. respectively. Carbonic acid gas, observed during the night from 1 to 5 o'clock A. M., is found to be 48 liters per 100 cubic meters of air. From 4 to 10 o'clock P. M. it is 108 liters. The mean night temperatures are 17.5 and for the day 19.7. The present ventilation is therefore very good in lowering the amount of carbonic acid, but has no great effect on the temperature. In the later tunnel (line No. 2) which has air openings and a motor fan system, the amount of carbonic acid is lowered to 100 liters per 100 cubic meters. In line No. 3, which is of more recent construction, the figure falls to 70 liters.

To Preserve String and Fishing Lines.—*a*. Lay them for an hour in a solution of glue and then in a solution of tannin. Then dry them and saturate them with oil. *b*. Cord for tree grafting: Lay in a solution of 10 parts of sulphate of copper in 100 parts of water, allow to drip for 24 hours, then dry.

THE ART OF GALVANIZING.—I.*

BY ALFRED SANG.

THE AGENTS OF CORROSION.

ONE of the most persistent problems which confront the worker in iron and steel is the prevention of corrosion. We cannot rid ourselves of the agents which effect the corrosion of iron without at the same time ridding ourselves of the agents which are essential to life itself.

Air is indispensable both to human respiration and for the formation of rust and other oxides, for which it supplies the oxygen; moisture is necessary for the formation of clouds, which make the earth fertile, and it also supplies the medium in which rusting takes place and hydrates the oxide; carbonic dioxide is an animal by-product and a raw material for the vegetable world, and the exchange of carbonic dioxide and oxygen, which is continually taking place between the animal and the vegetable kingdoms, is of vital importance. Then, on the other hand, rust is not readily formed, if at all, unless there be an acid present, and the acid which is most universally distributed is carbonic acid, or hydrated carbonic dioxide.

There is, as you see, a close relationship between the processes of living and rusting, but while human beings make up for the rusting or decaying of their tissues by nutrition, it has not yet been discovered how to feed or regenerate iron, and until such a discovery is made we are compelled to take our cue from the ancient Egyptians and resort to embalming.

METHODS FOR PROTECTING IRON AND STEEL.

There are two general ways of embalming iron to prevent its decomposition, which might be called, respectively, the non-metallic and metallic methods. In the non-metallic method the articles are coated with an organic substance, usually oil or varnish, the efficiency of which depends on its being more or less airtight; when coloring matter is added to the oil it becomes a paint, but I understand from authorities on the subject that a varnish free from pigments is preferable to anything else. The metallic method consists in coating the iron with some other metal, and it is this method which I have come to discuss with you.

THE COMPOSITE NATURE OF STEEL.

Iron rusts less readily than does steel; this is perhaps due to steel being a very composite material. In the iron, which forms the bulk of its composition, are dissolved or immersed a great variety of other substances; some of these are simple, such as graphite, silicon, and manganese, and others are compound, such as carbides, sulphides, phosphides, and silicides. The carbon compounds are very numerous and diversified, being due to different heat treatments; the best known are cementite, pearlite, and martensite. Just as variety is to some people the spice of living, so is heterogeneous composition the spice of rusting, in the present instance at any rate. Nor is this by any means a solitary instance; it is a well-known fact that chemically pure zinc is dissolved very slowly by certain acids, whereas the commercial product, especially if it be high in iron, is rapidly dissolved.*

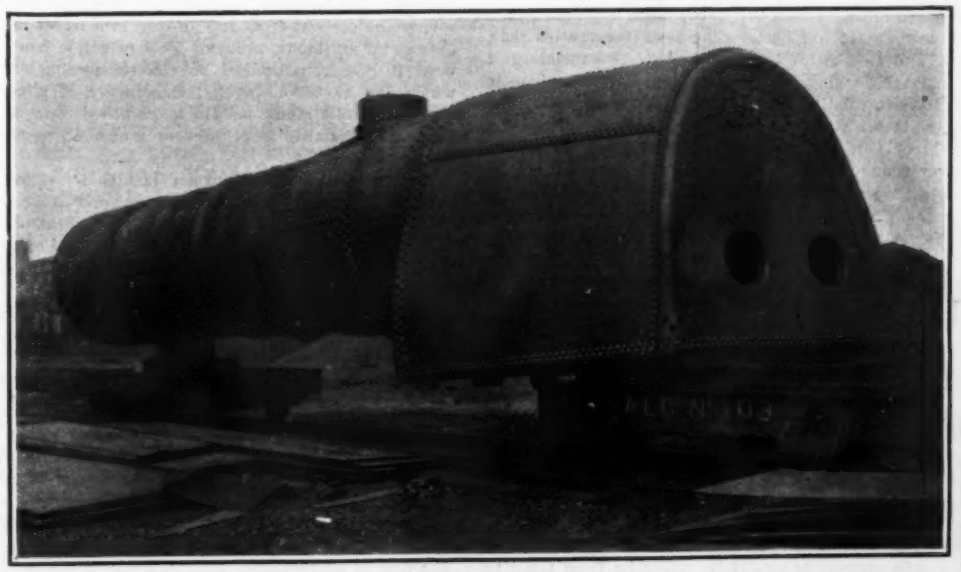
When steel is attacked by an acid pickle its surface becomes rough and pitted. This is due to the iron dissolving first and the impurities being left as a poorly adhering black powder. For some work which has to be coated, and especially if the coating is nonmetallic, it is desirable to remove the surface "rottenness" by means of the sand blast. The sand blast is often inconvenient or undesirable, but a high-pressure water jet is also effective, and will remove at the same time the gelatinous or colloidal salts of iron which are left on the surface of the steel.

METALLIC COATING.

If the metallic coating is considered merely as a garment which protects the iron article from atmospheric influences, the points which must receive special consideration are the closeness of the fit and the impenetrable qualities of the coating. A close fit is more readily obtained by depositing the metals electrically. In hot processes the uneven contraction of the coating and coated metals, the latter usually having the lower coefficient, will cause blisters, which are not always noticeable to the naked eye, but which are none the less present. This poor adherence, due to uneven contraction, is evidenced by the flaking, which will take place when the articles are bent.

With articles which do not undergo bending, such as castings, there may not be any flaking, but the air spaces are there just the same, and oxidation will take place under the blisters, out of sight, slowly but surely, if the air is given access. Unfortunately the air has free access to these spaces, because no hot coated surface which has not received a mechanical treatment in the hot state, such as rolling, is free from faults and crevices; especially is this the case in rough and irregular work like castings, where the variety of strains taking place at the moment of setting of the coating metal produces an equivalent variety of microscopical fissures. Through these fissures the air, moisture, and carbonic dioxide have free access to the iron.

An electrically deposited coating adheres a great deal better than does a hot coating, and this is the greatest point in its favor. Unfortunately, it is almost impossi-



THE FIREBOX OF THIS LOCOMOTIVE BOILER, 10½ X 9½ FEET, IS AS BIG AS A LIVING ROOM OF MODERATE SIZE.

THREE LARGE MALLET COMPOUND LOCOMOTIVES.

* Read before the American Foundrymen's Association, Philadelphia, Pa.

* The theory has been advanced by Weeren that this passiveness of pure zinc is due to the formation of a condensed layer of hydrogen on the surface, which prevents further action of the acid. It is difficult to see how the presence of iron would prevent this accumulation of hydrogen.

ble to obtain a surface free from pores. Every photographer knows how specks of dust will cause pin holes in his negatives. A particle of dust is more or less light proof and protects the point of the film on which it rests from the chemical action of light. In electrolytic work each speck of impurity prevents the metal ions of the electrolyte from depositing on the spot covered by the impurity and a pin hole or pore is the result. These pin holes are like wells with a spot of rust, a speck of dirt, or a particle of oil at the bottom, each of which was sufficient in itself to prevent the deposition of the coating metal, but none of which is able to prevent the access of the corroding agencies. Under the microscope, rust will be found to originate in all cases in the pores, and I have examined specimens where the rust seemed to fairly ooze out of them. If articles could be made perfectly clean before being coated, the electrolytic process would be perfect as regards the two points of quality required of a coating considered as a covering only.

THE COATING AS A MECHANICAL PROTECTION.

Considered merely as a mechanical protection, the coating should be resistant to impact and to abrasion, the latter being the most important. The soft metals, such as tin and zinc, do not stand up well against abrasion, but, unless their adherence be very defective, they will stand impact well, on account of their malleability at ordinary temperatures. It would be desirable to obtain a coating which would be as good a protection as zinc, but tougher and harder. Aluminium is being used with more success, and if the metal were cheaper it would become an interesting competitor of zinc.

DIFFERENT BEHAVIORS OF TINPLATE AND GALVANIZED IRON.

But there is a more important feature of metallic coatings to be taken into consideration. This feature I shall introduce by the following example. If you make an incision in the surface of a sheet of tinplate and a similar one in a sheet of galvanized iron and expose the two sheets together to the same oxidizing agencies, you will soon note a very great difference in the behavior of the two mutilations. The cut in the galvanized iron will rust very slightly or not at all and the zinc at the edges will be oxidized, but the cut in the tinplate will not only show much more rapid and intense oxidation of the iron but the corrosion will extend beyond the edges of the cut, and in spite of the tin. A pin hole in a galvanized sheet will not rust; a pin hole in a tinplate will spread like a star.

METALS IN CONTACT.

I must now call your attention to a few scientific principles which are all important when considering metallic coatings. In order to understand the reason for the different behavior of the galvanized iron and the tinplate, it is necessary to thoroughly understand what takes place when two metals are in contact. For the purpose of the present discussion we must consider four cases of metals in contact as follows:

1. In the presence of electricity.
2. In the presence of heat.
3. In the presence of corrosive agents.
4. Apart from any exterior agency whatever.

IN THE PRESENCE OF ELECTRICITY.

As regards the first case, it is important to note that copper conducts electricity better than does iron, iron better than tin, tin better than lead, lead better than zinc, and zinc better than antimony. The metals first mentioned are negative to those which follow; iron is negative in relation to zinc and zinc is positive in relation to iron. The conductivities of these metals are the reciprocals of their resistivities; in other words, the better conductivity of copper over iron is due to the smaller resistance which it opposes to the passage of the electric current. Again, the better the metal conducts electricity the less capacity it has for storing it. This is the same as in the case of heat; the poorer the body as a conductor, the more difficult it will be to heat it, but the longer it will take to cool. The wooden handle of a silver teapot does not heat up as well or as rapidly as does the pot itself, but when the teapot is cooled the metal part cools quickest and becomes colder than the handle.

If, now, two metals, say iron and zinc, are put in contact and immersed in an electrically-charged medium, the iron being the better conductor will not absorb as much electricity as the zinc, and there will exist what is known as an electromotive difference of potential. There will be a difference of electrical pressure between the iron and the zinc in contact, and therefore a steady current of electricity will flow from the zinc to the iron, and this current will be kept steady by the leakage, which is directly proportional to the absorbing power. If no leakage were possible, the potential of the two metals would reach the same level and they would be in electrostatic equilibrium equivalent to a closed circuit.

An apt comparison to what takes place would be that of two water tanks of equal dimensions, connected at the bottom and at the top by open pipes, and one tank having a larger intake at the top than the other. If both tanks are filled simultaneously by steady streams of water, the tank with the larger intake will fill more rapidly and there will be a continual flow through the lower connecting pipe from the tank with the larger intake to the tank with the smaller intake to maintain the level. When the tanks are full they will be in equilibrium, and if they are turned upside down the outflow through the intake pipes will be proportionate to the previous inflow and the current will be reversed, passing from the tank with the small outflow to the tank with the large outflow in which the level is going down more rapidly.

It is this operation of maintaining, or rather the effort to maintain the electrical level, which produces the flow between metals of different conductivity when they are in contact and immersed in an electrically-charged medium. The medium itself may be perfectly static, or at rest, but the flow from the iron to the copper will manifest itself as dynamic or moving electricity. Nothing in nature, be it material or immaterial, can be manifested to our senses unless there be a motion, a difference, a relation.

Electricity is always present on this planet, and everything is fairly impregnated with it. If, therefore, we bring two dissimilar metals into mutual contact we shall obtain a flow of electricity from one to the other, caused by an ineffectual effort to equalize potentials, which will produce sensible galvanic effects. The contact need not be direct. A suitable conducting connection, such as moist air, will act as an electrolyte and enable the action to take place, the space in between constituting what is known as a field of force. Besides atmospheric and telluric electricity, we are often called upon to take into consideration, in our engineering problems, the electricity artificially produced for industrial and domestic purposes, the diffusion of which "stray currents," as they are called, will hasten the corrosion of water pipes and structural steel even when they are imbedded in concrete.

The reverse of the order in which I have previously placed the metals in relation to their conductivities, i.e., antimony, zinc, lead, tin, iron, and copper, indicates the positive direction in which the current will flow from metals having the higher to those having the lower potential. It is known as an electromotive series.

IN THE PRESENCE OF HEAT.

The second case is that of metals in contact exposed to heat. The electrical conductivity of substances will vary with temperature, that of metals decreasing with an increase of temperature. There are notable exceptions to any generalization which might be attempted that the conductivity is inversely proportional to the temperature, and one of these exceptions happens to be iron.

When two metals in contact are subjected to heat, the voltaic or galvanic action of which I have spoken will be influenced either favorably or unfavorably because the thermo-electric series is different from the electromotive series which I have given you. The thermo-electric series runs as follows: Lead, tin, copper, zinc, iron, and antimony. The order of these metals indicates the direction in which the current tends to flow with an increase of temperature. This tendency may be—and is in most cases—exhibited as either a resistance or as an aid to the electromotive current; for instance, increase in temperature will reduce the current from zinc to iron in a lesser degree than from antimony to iron. This principle has been used in the construction of electric pyrometers in which the variation in the temperature of a couple formed of dissimilar metals is recorded very sensitively at a distance from the source of heat, by means of a galvanometer.

The galvanic effect between metals is, therefore, modified in a very complicated manner and to a considerable extent by the temperature at the point of contact. This galvanic action seems to be intimately related to the natural tendency toward chemical action exhibited by all substances in contact and to that chemical affinity which exists to some degree or other between all kinds of matter.

IN THE PRESENCE OF CORROSIVE AGENTS.

The third case is that in which corrosive agents are present which attack both of the metals. A decrease of electrical potential seems to aid chemical action and an increase of this potential opposes it. The metal toward which the flow of current is directed is, so to speak, oversaturated on account of the persistence of effect which, when it refers to magnetism, is called hysteresis, and its potential is greater than normal. The flow of current from zinc to iron will oversaturate the iron and will prevent its decomposition, when it is exposed to corrosive influences, whereas the zinc which is undersaturated is in poor physical condition to withstand chemical attacks. It will decompose into oxide and carbonate more rapidly than if it were out of contact with the iron.

If only one of the metals is attacked by the corrosive agents under normal conditions there will be no galvanic protection, and this is why nickel plating, which is unaffected by ordinary atmospheric conditions, is nothing more than a protective skin, and if it is partially removed the exposed surface of the iron will rust very readily. Copper plating is no better, and if the iron is exposed the galvanic action is slightly unfavorable, because the copper is in negative relation to the iron. Copper rolled over iron and then drawn forms a good protection, but in this case the iron is nothing but a core. Lead would be a good coating metal if it were only harder and more readily attacked by acids.

APART FROM ANY OUTSIDE AGENTS.

The fourth and last case is that of metals in contact without any exterior agents being taken into account. Careful investigation has shown conclusively that if two metals are placed in close contact there will be a slow exchange of molecules, which will result in the metals alloying at their surface. If great pressure is applied during this exchange the metals may be actually welded together. This action does not take place in a minute, nor even in a day or a month. It is very wonderful what pressure will do; certain salts in a finely powdered state have been compressed beyond a critical point where the cohesion became equal to that of the substance before it was pulverized, and even transparency was recovered. What enormous power must exist within the atom to bring about the same results by rapid and unimpressive reactions, such as the recovery of crystals by dissolving a pulverized substance and then evaporating it!

This exchange of molecules between metals in contact is a simple case of diffusion. The diffusion of metals takes a great deal longer than that of liquids or gases because the internal friction is vastly greater. If the molecular cohesion is reduced by fusing the metals, the alloying will take place as readily as when whisky and water are mixed to form the alloy which is known as a "high ball." If the metals could be brought to a state of vapor the diffusion would be practically instantaneous, and even if only one of the metals were in a state of vapor this should hasten the process to a considerable extent. I must ask you to take good note of this statement, because it has a very important bearing on the process and nature of dry galvanizing.

The effect of pressure is to hasten the action, but diffusion will always take place between metals provided there is some kind of contact. According to this theory, the metals of alloys should become more thoroughly incorporated with time, and a zinc coating which has passed through the early stages of its existence without being destroyed should, like wine and love, improve with age. The two metals should gradually become alloyed at their surface of separation. If the old Ninevites or Egyptians had produced galvanized work there would be people to worry over the lost art of alloying iron and zinc, just as others still persist in claiming that some useless art of hardening brass has been lost, although it has not even been proved as yet that it ever existed.

SPECIFICATIONS FOR AN IDEAL COATING.

On looking back at the four cases of metals in contact, which I have discussed, you will readily see that all are closely related, and that they must in all normal cases be present at one and the same time. What, then, are the specifications for an ideal metallic coating for iron?

1. It must be as far as possible from the iron toward the positive end of the electromotive series and must fulfill the same requirements in the thermo-electric series.
2. It must be affected by the same agents which corrode the iron.
3. It must present as large a surface as possible to the corroding agents.
4. It must be in very close contact with the iron.

Zinc is, of all the commercial metals, the one which most closely fulfills the first and second requirements; the third and fourth, in regard to surface exposed and contact with the iron, are matters of process, and I shall, therefore, now proceed to describe the various processes which have been used to apply zinc to metal surfaces. But before doing so I would point out that all the principles which I have enumerated apply as well to the salts of the metals, and that is undoubtedly one reason why red lead and zinc white give such good protection against corrosion.

COLD GALVANIZING.

In the early years of the last century the process of electrolytic zincing, which is nowadays known as cold or electro-galvanizing, was first discovered, but until about ten years ago the lack of suitable equipment prevented its commercial application. The articles to be treated by this process are first thoroughly cleaned of scale, rust and grease by an acid pickle, sand blasting, hot lye, or by other means, singly or in combination, and are then placed as cathodes in a solution of some salt of zinc—usually the sulphate—in presence of zinc anodes which regenerate the solution, while a current of low voltage is passed through the arrangement and deposits zinc from the solution upon the articles. Numerous factors must be taken into account: the composition and temperature of the bath, the voltage and density of the current, the quality, shape, and posi-

tion of the anodes, and many other points which are all of prime importance if the results are to escape first criticism and then corrosion.

The surface of an electrically galvanized article is mat or frosted, provided the work has been properly done. It always shows a few pores. If improperly done, or if the work was not perfectly clean before treatment, it is either honeycombed with pin holes or spongy. Above a certain limit of thickness below which the coating is worthless, first-class electro-galvanizing is superior to hot galvanizing, and it is cheaper to produce where automatic machinery can be employed, although less zinc is deposited than by a hot dip. This is no doubt due to the better contact between the zinc and iron.

HOT GALVANIZING.

Sixty years ago the process of hot galvanizing was introduced on a commercial scale. It consists in dipping the articles into a bath of molten spelter, with or without other metallic additions, at temperatures ranging from 750 deg. to 900 deg. F. The articles must be first cleaned, as for electrolytic work, but a slight falling short of perfection does not have such disastrous effects on the quality of the result. Very heavy pieces may be heated before dipping, so as not to chill the bath. The coating is crystalline or amorphous, and does not adhere as perfectly as does the electrolytic one. Properly treated sheet metal goods have an attractive spangled appearance, but most articles look like castings and sharp edges are lost. Metallic chlorides are used as fluxes. They are expected to remove the injurious salts of iron left by the pickling, but it is a question if it is not another case like the introduction of rabbits in Australia, and if they themselves are not the main cause of the decay, which starts underneath the coating in hot galvanized work.*

DRY GALVANIZING.†

The latest process for applying a zinc coating is the dry process, and I am going to endeavor, not only to describe the process itself, but to show also how it fulfills the requirements which I have indicated; how it permits the extension of galvanizing to articles which have never been protected in this manner, and how by divulging the mystery of the nature of zinc dust it permits us to speculate along new lines in metallurgy, which may lead to the discovery of some principles of great industrial value.

The process of dry galvanizing or Sherardizing metals was awarded a gold medal at the St. Louis Exposition of 1904, and the president's gold medal for 1905 was presented to its discoverer by the British Society of Engineers. The inventor, Sherard Cowper-Coles, is one of the most eminent metallurgical engineers in Europe, and is well known for his reintroduction on a commercial scale of the process of electric galvanizing, the regeneration of electrolytes by the coke and zinc dust filter, the electrolytic spinning of copper into sheets, wire, and other forms, and innumerable other inventions and improvements in connection with the electro-deposition of metals.

THE PRACTICE OF DRY GALVANIZING.

For the purpose of Sherardizing the articles are placed after cleaning in a retort, usually a drum, and are covered with zinc dust, which is commonly called blue powder, and is the flue dust, and, therefore, a by-product of the zinc-smelting furnace, known as the Belgian furnace. It contains, as a rule, from 75 to 90 per cent of pure zinc. The supply of zinc dust is ample at a price below that of spelter, and if the demand increases it can be produced in any quantity that may be required. A small amount of powdered charcoal is added to prevent oxidation of the zinc by the air inside the retort at the beginning of the operation, and the receptacle is closed and heated to a temperature about 200 degrees below the melting point of zinc.

Ideal conditions would obtain if the air were exhausted from the drums. Where the size of the plant warrants the control of the zinc dust consumption to within so fine a margin, the drum might be filled with some inert gas, such as carbonic dioxide, which is supplied to soda fountains and other users in steel cylinders at very low cost. It is, however, to be feared that if the temperature is allowed to go too high the carbonic dioxide might act as an oxidizer on some of the dust.

By Sherardizing, a homogeneous deposit of zinc is obtained, varying in thickness according to the length of time, its lower portion being an alloy of zinc and iron or of zinc and copper, as the case may be. In the case of copper the alloy is a true and hard brass. The drum is occasionally turned a fraction of a revolution to insure an even coating where the articles are crowded together, and the heating may last from a few minutes to several hours and two or three drums can be used in connection with one furnace.

A Sherardized surface resembles in general appearance an electrically coated surface. It is, however, of a soft silver gray, more lustrous and metallic, and, on that account, it is to most people more pleasing to the eye, and it is distributed with great uniformity, which is not the case in hot galvanizing. Whereas in hot galvanizing the amount of zinc which is alloyed to the metal of the article is very small, and most of the coating forms an exterior perishable skin, in Sherardizing the coating is thoroughly incorporated with the metal which it protects, forming an alloy having the appearance of pure zinc but much harder and more durable. It is on account of this thorough alloying that the protection afforded by dry galvanizing is so superior to that afforded by either hot or electric galvanizing. The zinc having penetrated the iron, the old surface cannot be recovered by either chemical or mechanical means.

If an excessive amount of zinc is deposited by Sherardizing, the outside surface is composed of zinc somewhat hardened by the presence of a small percentage of iron, and zinc dust accumulates and clusters in a way which renders the surface rougher and much less attractive in appearance under magnification than it is to the naked eye. No special advantage is derived from the additional expense unless the conditions under which the articles are to be used are exceptionally severe.

The process of dry galvanizing is not confined to zincing; the dusts of antimony and of other metals can be used in a similar manner. The fact that zinc dust, even at temperatures higher than its melting point, does not melt or cake is of great value in Sherardizing, as it eliminates the danger of spoiled work from carelessness in handling the temperature. Furthermore, zinc dust containing as little as 35 per cent of pure metal can be used. The presence of the oxide is probably necessary, as it seems to play a part in the process.

SOME ANOMALIES IN THE NEW PROCESS.

But why is it that zinc dust acts in this peculiar manner, depositing zinc at a temperature several hundred degrees below its melting point, and why is it that the comparatively cold zinc alloys itself to the iron or other metal when the molten zinc of the hot process fails to do so, or at best only does so in a cumbrous, limited way? I can only answer these questions by giving you my own theory of the nature of zinc dust and of its action under the conditions of dry galvanizing. This theory is quite new to the very best of my knowledge, and was not published by me until quite recently.* It is founded on observed facts, but is not entirely empirical, because so far it has seemed to satisfy all the theoretical tests to which I have been able to put it and it answers a number of unexplained phenomena which I shall mention later.

(To be continued.)

* The fumes given off in hot work are injurious to machinery, and in a manufacturing concern it is necessary to erect a separate building for this work.

† Patented.

NOVEL USES OF PEAT.

IN GERMANY the uses to which peat has been put are many, and the consumption is constantly increasing. For bedding for stock only the second and third layers of peat are used. The blocks of peat are dried by air or in a kiln; they are then shredded by machinery, and then sifted, after which the peat is compressed and packed in bales by means of slats of wood and iron wire. The amount of bedding necessary per head of cattle is one hundredweight per year for every hundredweight of the animal's weight. Many sanitary and other advantages are derived from the use of this kind of bedding.

For fodder, only the top layer is used, which consists of moss and the fibers of partially-dried parts. The dried peat is then ground and sifted and mixed with molasses in the proportion of 20 to 25 of peat and 70 to 75 of molasses, obtained in the manufacture of sugar from beets. This product is guaranteed to contain 35 to 40 per cent of sugar. This fodder is used either alone or mixed with other food, as corn, potatoes, etc. The peat in this mixture counteracts the laxative effect of the molasses, and in the whole forms a wholesome food for horses, cattle, and swine; and as the acid of the peat seems to neutralize the alkalies of the molasses, the latter are rendered harmless, and the mixture has a sweeter taste than molasses alone. When due precaution is taken, the mixture keeps well. Horses fed with this develop glossy coats, gain in appetite, and are free from colic. Neat cattle are said to become less subject to "foot and mouth disease," and in the case of swine thus fed, that the unpleasant smell of butyric acid disappears from the sty and disease generally diminishes. The addition of 4.4 pounds to the daily feed of milch cows is said to increase the daily yield of milk about 0.55 gallon. In the province of Hanover from 10,000 to 15,000 tons are used every year, while Germany as a whole consumes 150,000 to 200,000 tons.

The value of peat for fuel is shown by the fact that it contains 54 per cent of carbon against 50 per cent in wood, 70 in soft coal, and 83 in hard wood.

The so-called "Torfmull," or turf dust, is sifted out of peat and used for packing fruit, such as tomatoes and other products, while "Mull," a by-product of peat, is used in potash works as a filter.

* Electro Chemical and Metallurgical Industry, May, 1907.

THE RECOVERY OF TIN FROM TIN-PLATE.

BY far the largest proportion of the tin used in the arts is employed for making tin-plates, and these, in turn, are mainly used for making the tins in which various comestibles are preserved. The total weight of the tin on the plating is said to average five per cent of the total weight of the sheet; and there has been in the past great difficulty in recovering this tin by a commercially profitable process, in spite of the high price of the metal. That contained in the solder used in making the joints of the tin can be, and is, recovered by simply heating the tins sufficiently hot to cause the solder to flow; but this process is useless as a means of recovering the rest of the metal. According to the Electrotechnische Zeitschrift, however, this feat is now being successfully accomplished at Copenhagen by the Bergsoe process. In this a solution of stannic chloride is passed over the tinned surface, when it takes up further tin forming the stannous salt. The latter is then electrolyzed, the additional tin dissolved is deposited, and stannic chloride reformed. The tins can, it is stated, be treated without requiring a preliminary cleansing. A hole is punched in the bottom of each, and a number are then placed in a basket, in which they remain during the whole of the subsequent treatment. When filled, the baskets are placed in a series of tanks, through which flows a two per cent solution of stannic chloride. As this solution flows from tank to tank it gradually becomes richer and richer in tin by forming the stannous salt of the metal, as explained above. From the last tank of the series it is raised into the electrolytic vats by a pump constructed entirely of brass, so as to be unacted on by the fluid passing through. Here the stannous chloride is again reduced to stannic chloride, which is returned to the dissolving vats, whence it picks up more tin, to be again regenerated by electrolysis. The process is therefore a cyclical one. The tin is deposited in small crystals measuring about 1/50 inch long. Being perfectly pure, it is salable at the same price as Banca. The energy expended in the electrolysis is said to be 47 kilowatt-hours per ton of the metal recovered. Though, as stated, the process is a cyclical one, the same solution cannot be used for more than three or four rounds of the vats, since it becomes charged with chloride of iron.

SPONTANEOUS IGNITION OF COAL.

THE old hypothesis suggested by Liebig, according to which the spontaneous inflammation of coal is due to the oxidation of the pyrites, can no longer be maintained. Spontaneous ignition, as pointed out by Dr. Heideprim (Welt der Technik), would seem rather to be attributable to a direct oxidation of the carbon. In fact, carbon when heated has been found eagerly to absorb oxygen from the air, and this heating effect can be increased until ignition occurs. The part played by moisture in the process has not yet been determined. The physical conditions of the carbon (hardness, size, etc.) are other facts influencing the process. In connection with a recent investigation of three hundred cases of self-ignition, all kinds of mineral coal apart from anthracite were examined. In most cases the ignited coal was ordinary coal, and less frequently nut coal or coal dust. The higher the layers, the more readily will self-ignition take place. An efficient ventilation by channels in the coal layers and the thermometrical recording of temperatures by long thermometers inserted in the coal have been found to be good preventive measures, while the only available means of extinguishing such fires has been found to be a transfer of the coal and simultaneous flooding.

THE CAUSE OF SOFT-SHELLED EGGS

POULTRY writers, since the time the Shanghai rooster first invaded Boston, have been repeatedly telling us that soft-shelled eggs were caused by an insufficiency of lime in the food consumed by the hens. Such, however, is not the case. The soft-shelled egg is a case of arrested development, due to nervous interference with the functions of the oviduct. The laying of incompletely developed eggs corresponds to abortion in mammals, and can likewise be brought about by extreme mental disturbance. In experiments conducted at the Kansas Experiment Station the writer was able to cause the production of soft-shelled eggs by continued excitement of confined hens. It was also shown that the hen's system on an ordinary diet contains enough calcium carbonate for the formation of about five or six eggs. If lime was withheld from the food, the hen after having laid this number of eggs, will stop laying. When lime was given in limited quantities the hens laid apparently normal eggs, but only as frequently as the lime furnished would supply shell material. Careful weighings proved that eggs thus produced, though apparently normal, were actually thinner-shelled than normal eggs from the same hen. But little is known about the process and control of egg formation, and further study should yield facts of both scientific interest and practical bearing.

AN AERONAUTICAL OBSERVATORY.*

THE ELABORATE EQUIPMENT OF A MODEL INSTITUTION.

BY DR. ALFRED GRADENWITZ.

THE aeronautical observatory recently erected in the neighborhood of Lindenberg, in the Prussian province of Brandenburg, is destined to become a center for investigations of the atmosphere by means of kites and balloons. Through the courtesy of Dr. R. Assmann, director of the observatory, we are enabled to describe and illustrate this unique institute.

Some difficulty was experienced in choosing a convenient site for the observatory. The proximity of large cities is objectionable in experimenting with captive balloons and kites, as the steel wires of the latter are apt to interfere with electric conductors. Furthermore, a taut wire may be almost invisible at a short distance away and if it should cross a street at a low level it will become a menace to car drivers, cyclists, etc.

The observatory comprises a dwelling house for the director, one for employees, an office building, an engine and workshop building, a balloon hall, and a winch shed. The observatory is lighted by electricity throughout, the generator being driven by a 30-horse-power suction gas motor. All surplus energy is stored in an accumulator battery of 120 cells. The engine house contains, in addition to the gas generator and cleansing apparatus, a Lilienthal steam boiler with serpentine tubes, supplying steam to a 7-horse-power reserve engine, and a still for generating any distilled water required for the accumulator battery and similar purposes. The plant also supplies current used for power purposes, namely, for operating a large number of machines and instruments, generating the hydrogen required for filling the balloons and actuating a refrigerating machine.

The hydrogen gas is generated in an electrolyzer, constructed by the Oerlikon Machine Works, and which is designed for decomposing water into its components. This apparatus comprises 95 cast-iron plates, provided with vertical grooves on each side adapted to register with the grooves of the adjacent plates. Between each two adjoining plates, which are forced strongly against one another by some sort of filter press, there is placed an asbestos diaphragm, sealing the grooves, so that the hydrogen and oxygen

WINCH HOUSE WITH AUXILIARY KITE HAULED IN.

gas bubbles generated by the electric current will rise toward the collecting groove, in order thence to be exhausted through the conduits placed to the left and right respectively. The liquid used as electrolyte is a 10 per cent solution of pure potash in distilled water. The working tension is 220 volts. The hydrogen is stored in a gas reservoir of 150 cubic meters (196 cubic yards) capacity, whereas the oxygen is exhausted into the air.

The carbonic acid ice-making machine installed in the same room comprises a compression pump liquefying carbonic acid under a pressure of 70 atmospheres. On removing the pressure, the acid enters an extensive serpentine coil traversing the refrigerator, and after cooling down the liquid contained in the latter to a temperature of 13 deg. to 15 deg. C., returns to the compressor to be again liquefied.

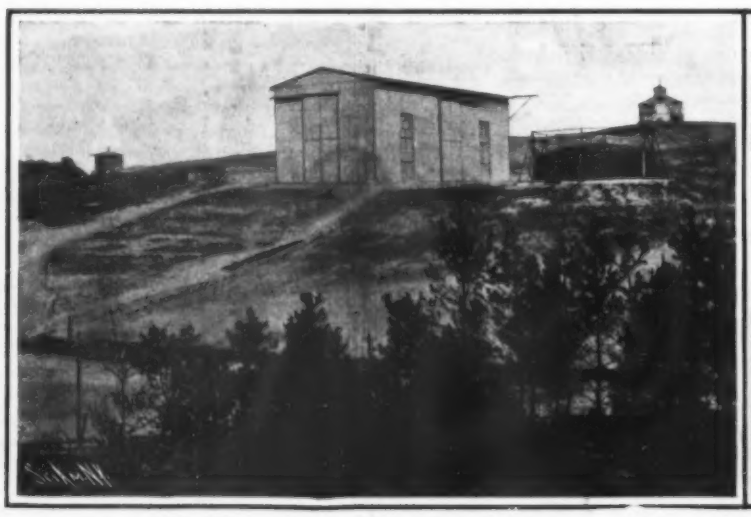
The workshops comprise a locksmith's shop, a workshop for fine mechanics (for repairing instruments and occasionally constructing some new apparatus) and a kite joinery. The machine tools used in all these shops are driven by electric motors.

In the testing room there are installed several air pumps for producing high vacua. In testing the anemometers used in connection with the Marvin recording apparatus there is used a Sirocco fan, directly connected to and operated by a ½-horse-power continuous-current motor running at 1,700 revolutions per minute. The speed of the issuing air is controlled by means of diaphragms.

The balloon shed is provided with sliding gates on all sides, so as to allow recording balloons to be always launched from the leeward side. The shed contains fans, apparatus for testing steel wires, and connections to the gas reservoir and other devices.

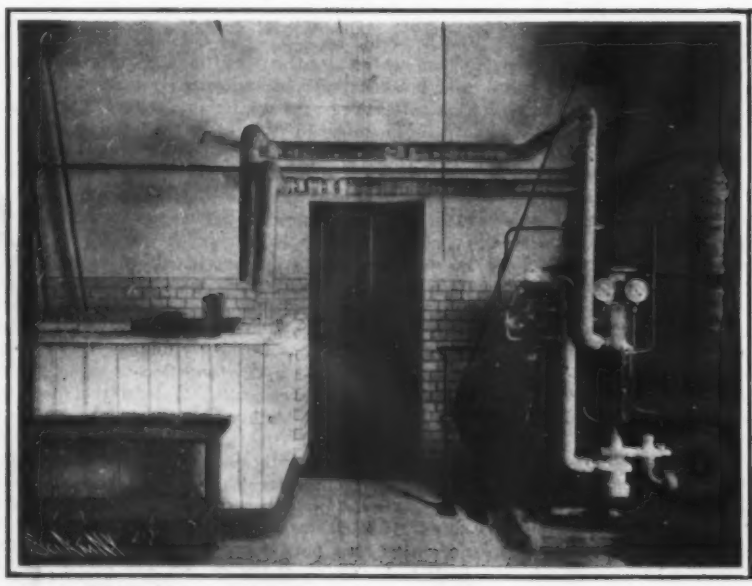
The winch house is located on a locomotive turntable, its side walls being lined inside with wood, and outside with undulated sheet iron, the interval being filled with ashes. The mechanism for rotating the house is of very convenient construction. On the outermost platform of the winch house there is placed a launching pulley, from which the wire is connected to the kite. The wire, running over a dynamometer roller at an obtuse angle, will produce a downward pressure on the roller and its springs, the pull being read from a scale. From the dynamometer roller the wire is carried to the outermost groove of the traction pulleys, and after running around the latter in four windings, returns to the distributing pulley arranged above the main drum, which by a reciprocating motion

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

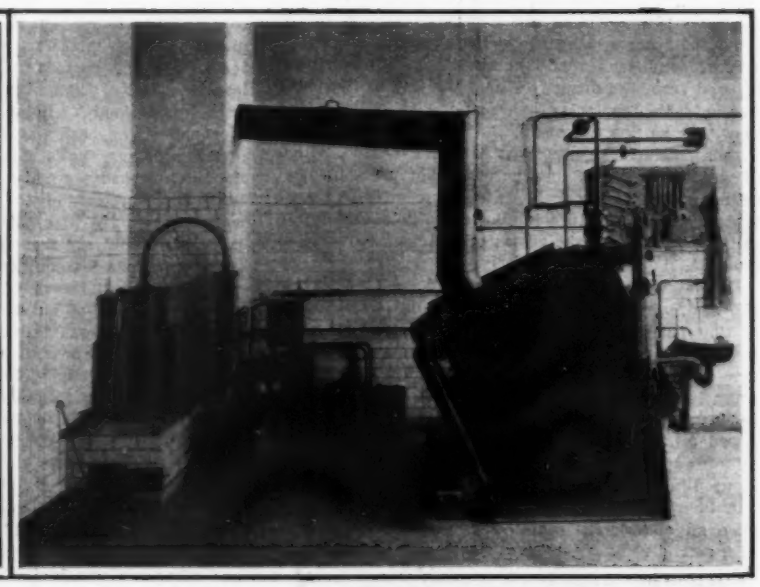


BALLOON SHED, GAS TANK, AND WINCH HOUSE.

WORKSHOP FOR EXPERIMENTAL WORK.

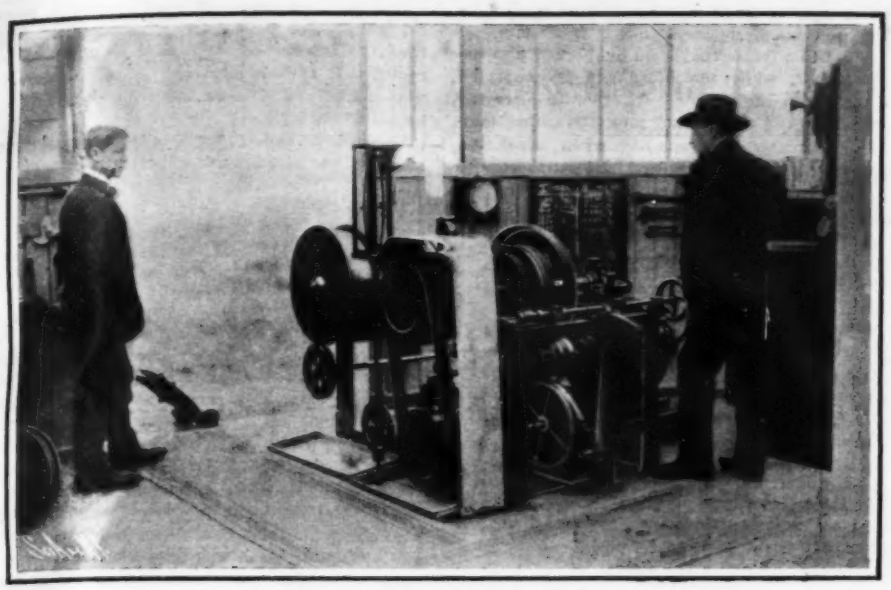


CARBONIC ACID REFRIGERATING MACHINE.



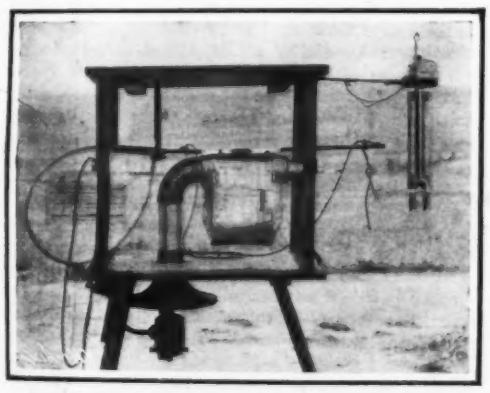
LILIENTHAL SERPENTINE-TUBE BOILER.

AN AERONAUTICAL OBSERVATORY.



INTERIOR OF THE WINCH HOUSE.

produces a uniform winding or unwinding of the wire. From the latter the wire is taken to the main drum, the capacity of which suffices for a length of 20,000 meters (21,873 yards). For adjusting the recording apparatus before and after ascensions an apparatus is used which is located outside of the winch house, and is operated by a small electric motor. A meteorograph of the Assmann pattern, permanently turned toward the wind, and the aspiration of which is produced by a similar motor, is used for recording the air pressure, temperature, and relative moisture.



ASPIRATOR FOR ADJUSTMENT OF RECORDING APPARATUS.

The regular work to be performed at the observatory comprises at least one daily ascension, independently of the conditions of the atmosphere. Special attention is to be paid to the daily period of atmospheric temperature. In the case of specially favorable weather, five ascensions per diem (partly by day and partly by night) are to be made for several days successively, the ground thermometer being read at the same time; while in connection with the international balloon ascensions held once a month, these experiments are made even more frequently.

Apart from the ordinary observations of meteorological stations (determining maximum and minimum temperatures of the surrounding air, moisture of atmosphere, amount of rainfalls, conditions of sunshine, and ground temperature) special attention is paid to recording by means of balloons and kites the average temperatures and wind speeds at different heights of the atmosphere. An interesting fact brought out by these experiments is that the fall of temperature in the lowermost 3 kilometers of free atmosphere is considerably slower than in the mountains, the free atmosphere thus being warmer than mountain air.

The programme of the observatory further includes:

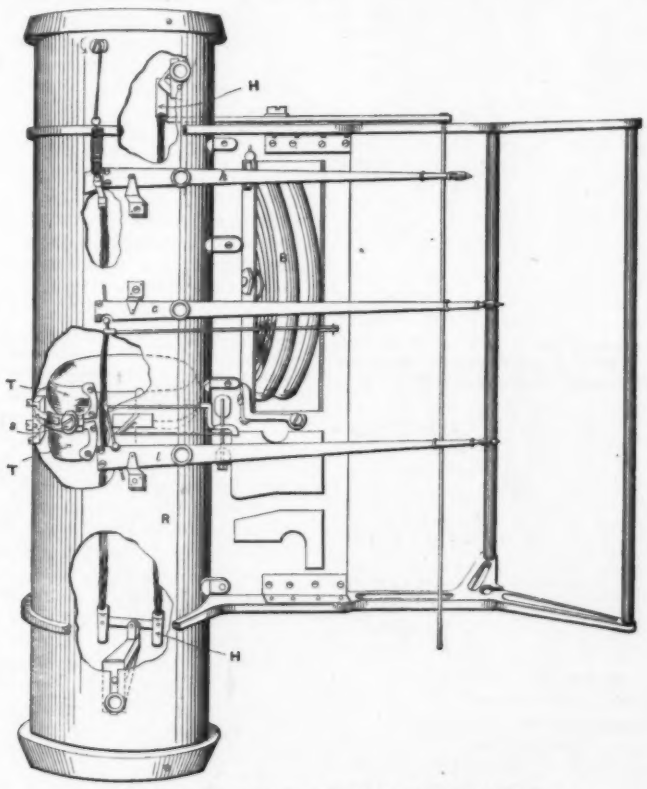
Investigations on atmospheric electricity, comprising measurements of the electric potential, observations on ionization, conductivity, electric dispersion, and the resulting vertical conduction current. As the factors in question are difficult to record with automatic instruments, their determination will for the time being be reserved to manned balloon ascensions.

Determinations of Sun Radiation.—Investigations on atmospheric radiation have been carried out with increasing interest in the course of the last few years, together with temperature measurements, the compensation pyrheliometer constructed by Angström affording a scientific basis for such researches.

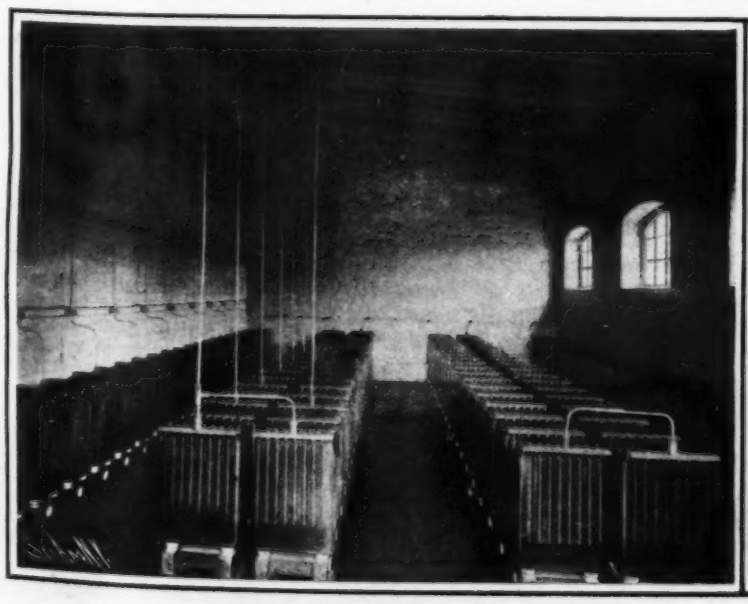
Determining the Percentage of Dust in the Air.—These supplementary observations to the work on atmospheric electricity, which are of special meteorological interest for the theory of the formation of clouds and rains, have been made in connection with several recent ascensions.

Measuring the Vertical Component of the Speed of Wind.—A special difficulty encountered in connection with these determinations is the variability of anemometer constants; these instruments will therefore have to be improved on.

Determining the Percentage of Water in Clouds and Photographing the Latter.—The work of cloud photography is being carried out especially by the younger members of the staff.



DETAILS OF THE MARVIN RECORDING APPARATUS.



THE STORAGE BATTERY ROOM.

APPARATUS USED IN GENERATING HYDROGEN.

AN AERONAUTICAL OBSERVATORY.

Astronomical topographical determinations from the balloon have been further performed with much success.

While kites and "ballons-sondes" are extremely valuable in carrying out these various measurements, manned balloon ascensions have to be resorted to in many cases, as well as for supplementing the data supplied by the former.

As regards the instruments used in connection with the *daily* kite and balloon ascensions, the Marvin kite apparatus described in the following is employed almost exclusively:

In the detail view, *R* is a wide metal tube comprising several annular Bourdon tubes *T* filled with alcohol, which serve as thermometer tubes. One end of the latter is fixed to a frame connected by a screw *s* to the wall of tube *R*, while the other end is connected through levers to the style *t*. In order to alter the absolute position of the thermograph style, the Bourdon tubes are rotated by means of a small screw situated close to screw *s*, which being rigidly connected to a small pinion meshes with a rack on the frame mentioned.

For recording atmospheric pressure two large aneroid boxes *B* are used which actuate the style *b* through a lever transmission.

The hair hygrometer *H*, which serves to determine the moisture of atmosphere, is arranged alongside the tube *R* and comprises two parallel hair bundles, so connected that any alterations in their length are added. The end of one of these hair bundles is directly connected to the style *h*.

To the front end of tube *R* is fitted the Assmann anemometer, the paddlewheel of which transmits its rotation to a worm against which a lever *c* rigidly connected to the style *h* is slightly forced. The number of contacts effected in a given time immediately gives the speed of the wind, the style recoiling to its position of rest after each rotation of the worm.

THE THEORY OF THE GYROSCOPE.

AN EXPLANATION OF ITS PHENOMENA.

THE interest aroused by the exhibition of the model of the Brennan monorail car at the recent conversazione of the Royal Society renders the moment opportune for a few elementary notes on the theory of the gyroscope. For our present purpose the gyroscope may be replaced by a thin ring, such as represented in Fig. 1. Suppose this ring is spinning about the axis *X X* in the direction shown by the arrow, and a couple *P P* is applied tending to turn it about the axis *Y Y* as represented. Then the ring, if perfectly free to move, will not turn about the axis *Y Y*, but about axis *Z Z* in the direction indicated by the arrows $\mu\mu$. This is at right angles both to the axis of spin and to the axis of the acting couple. It is for this reason that a top rights itself and reaches the position known as "sleeping." If spinning in the position indicated in Fig. 2, there will be a frictional resistance at *E*, the point of contact with the ground, which will have a moment about the center of gravity of the top. The latter will, therefore, on the principle stated, move at right angles to this moment, and at right angles to its axis of spin, and thus be raised to the vertical position. The energy required for effecting this work is obtained from the kinetic energy of the spin.

The reason why a spinning ring, such as is represented in Fig. 1, moves at right angles to the couple acting on it will readily be understood if we consider the motion of a particle of the ring when it is both spinning about the axis *X X* and rotating about the axis *Z Z*. At *A* the particle has a velocity at right angles to the instantaneous plane of the ring equal to $r\omega$, say, where r is the mean radius and ω is the angular velocity of the ring about the axis *Z Z*. By the time this particle reaches the point *B*, however, its velocity relatively to the instantaneous plane of the ring has been destroyed, so that a force must have acted on it in the opposite direction to the velocity destroyed; that is to say, in a direction at right angles to the plane of the ring. In passing from *B* to *C*, the particle acquires velocity again, and at *C* is moving in a direction at right angles to the instantaneous plane of the ring with a velocity $\mu = r\omega$, equal in amount, but opposite in direction, to its velocity at *A*. To generate this velocity a force must have acted from *B* to *C* in the direction of the acquired velocity; that is to say, in the same direction measured relatively to the instantaneous plane of the ring as the force which acted from *A* to *B*. Similarly, in passing from *C* to *D* and from *D* to *A*, a force is again necessary to destroy and generate velocity relatively to the plane of the ring, and this force will obviously be opposite in direction to that which acted on the lower half of the ring; that is to say, the two constitute a couple tending to turn the ring about the axis *Y Y*, while the actual motion takes place about the axis *Z Z*. Hence, to maintain the ring rotating about the axis *Z Z* while it is spinning about the axis *X X*, a couple tending to turn it about *Y Y* must be applied. It should be noted that this couple does no work, since no rotation takes place about *Y Y*. In a sense it is thus analogous to the centripetal force developed in a string when a ball at the one end of it is whirled round, and the other end held fast.

A numerical relation between the speed of the spin, the speed of the rotation about *Z Z*, which is known as the rate of precession, and the couple *P P* is easily obtained.

Consider the particle at *F*, Fig. 3; then if it is rotating about the axis *Z Z*, as well as moving round the center *O*, its velocity of motion measured relatively to the plane of the ring at any moment is obviously given by $v = r\omega \sin\theta$, where r is the mean radius of the ring and ω the angular velocity about the axis *Z Z*.

Hence

$$\frac{dv}{dt} = r\omega\cos\theta\frac{d\theta}{dt}$$

but $\frac{d\theta}{dt}$ is the angular velocity of the particle about the center *O*, that is, of the spin; so that calling this a we have

$$\frac{dv}{dt} = r\omega\cos\theta$$

If *M* be the total mass of the ring, and $d\theta$ the angle subtended by the particle under consideration, the mass of the latter—m, say—is obviously

$$m = \frac{M\,d\theta}{2\pi}$$

The force acting on a particle is equal to the mass multiplied by its acceleration, or

$$f = m\frac{dv}{dt} = \frac{M}{2\pi}\,d\theta \times r\omega\alpha\cos\theta$$

$$= \frac{Mr\omega\alpha}{2\pi}\cdot\cos\theta\,d\theta$$

The moment of this force about the axis *Y Y* is obviously $f r\cos\theta$, and the total couple—C, say—maintaining the rotation is

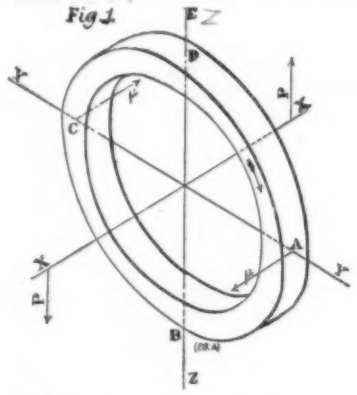
$$C = \Sigma f r\cos\theta = \int_0^{2\pi}\frac{Mr^2\omega\alpha}{2\pi}\cdot\cos^2\theta\,d\theta$$

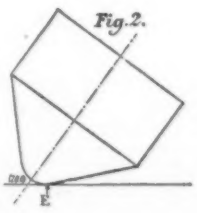
$$= \frac{Mr^2\omega\alpha}{2}$$

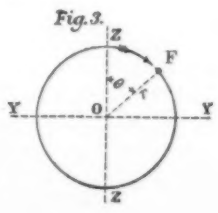
This formula may be used when the gyroscope takes the form of a flywheel, while if it has the shape of a solid disk,

$$C = \frac{M\rho^2\omega\alpha}{2}$$

where ρ is the radius of gyration of the disk about its center.







As a numerical example, assume the weight of a ring gyroscope as 50 pounds, and its radius as half a foot, and let it precess at angular velocity of unity—that is to say, let it make one turn in 3.14 seconds, while its angular velocity of spin is 200 π per second, equivalent to 6,000 turns per minute, then

$$C = \frac{50 \times \frac{1}{4} \times 200\pi \times 1}{32.2} = 245 \text{ foot pounds}$$

It is thus evident that a relatively light gyroscope can balance a very considerable deflecting couple if it is allowed to precess even comparatively slowly.

Suppose the rate of precession—that is to say, suppose in the case of the Brennan apparatus that the angular velocity of the gyroscope about the vertical axis of its supporting gimbals—is increased, it can then support a stronger deflecting couple; or if the latter remains constant, there will be an unbalanced couple tending to turn the gyroscope about the horizontal axis of its gimbal suspension, in a direction opposed to that of the original deflecting couple, and this will, in the case of the Brennan car, lift the latter till its center of gravity is above the point of support. This acceleration of the precession is obtained by means of a roller on a prolongation of the gyroscope axis, which comes, when the gyroscope precesses, into contact with guides fixed to the casing in which the device is inclosed. The friction between the roller and the spindle tends to cause the former to rotate with the spindle, and thus to roll itself along the guide with which it is in contact. This causes the gyroscope to precess more rapidly, which, as pointed out above, is exactly the action required to cause the car to move in opposition to the original deflecting couple.—Engineering.

THE STANDARDIZED STAIRCASE.

A SYSTEM of standards is the order of modern life, and in many directions standards are convenient if not, in some cases, indispensable. We have, for instance, standard gages for railways and tramways, standard threads for various screws, standard sizes for boots, shoes, and gloves, standard qualities for articles of food, standard weights and measures, coinage, and so on. But there are still some directions in which the need of a standard is not only indicated but is urgent. The desirability, for example, of standardizing the steps of all staircases is seen in the fact that so often a fall on the staircase is due to the irregularity in the height of the steps. A common cause of accident on the staircase is the kicking of the edge of a stair when ascending. In descending, also, an irregularity in one step may easily upset the equilibrium of a person. To the aged and infirm the descent of an irregularly stepped staircase is a source of terror. Yet how many staircases are constructed absolutely alike as regards the height of the steps? We should say very few; and not only is there little uniformity existing between different staircases but the steps themselves in the same staircase are often irregular. Staircases and the steps in them should be standardized; there should be uniformity of height and breadth, and in regard to the latter there should be room enough on the step to accommodate the whole foot from toe to heel, so that there is no undue call on the energies when ascending, as by going on tiptoe, so to speak, or any feeling of insecurity when descending by reason of there only being room for the heel. Serious falls on staircases are by no means rare and a common cause of such accidents is the fact that staircases are not standardized. Even in dark places the staircase, if standardized, would be more safely negotiated than a well-illuminated but irregular stairway. The perils of an ordinary ladder would be enormously increased if the rungs were placed at irregular intervals.—Lancet.

The Great Northern Railroad of Great Britain is carrying out experiments with a new system of extending warning of the approach of a train at level crossings. A large bell is fixed to a post at the crossing. Some distance in advance of the crossing a small attachment resembling a treadle is placed beside the line, this being in connection with the bell. The train in passing this treadle causes it to be depressed, thereby ringing the bell violently and continuously. At a distant point beyond the crossing is another device, the passage of the train over which throws the bell out of action. The apparatus is of a simple character, the first treadle being actuated partly by its own weight and partly by mechanical action. The bell can be operated by trains traveling in either direction. At the crossing a large notice is displayed, warning all not to cross the line while the bell is ringing. The device has been set up at two particularly dangerous crossings upon the railroad in the neighborhood of London, where many serious accidents from time to time have occurred, owing to sharp curves which prevented persons from seeing or hearing the approach of a train until too late. With the audible device warning is given in ample time, so that those who may possibly be half way across the track are still allowed plenty of time in which to gain safety. Owing to the success of the apparatus, efforts are being made to urge the railroad authorities to extend the system to other dangerous crossings similarly situated on sharp curves.

SPECTROSCOPIC PHENOMENA IN STARS.

THE STELLAR EVIDENCE OF CHEMICAL AFFINITY AND THE QUESTION OF STELLAR MOTIONS.

In two lectures delivered at the Royal Institution Mr. H. F. Newall, M.A., F.R.S., president of the Royal Astronomical Society, gave an interesting review of the state of our knowledge of stellar spectroscopy. In the first of the lectures Mr. Newall dealt particularly with the chemical aspect of the phenomena; in the second he dwelt on the multiple nature of the stars and on their motions, as revealed by spectroscopic evidence. Introducing his subject, he pointed out that the salt vapor, glowing in a Bunsen burner, showed us the sodium lines, but gave no clue as to the presence of the chlorine in the vapor. While the dark gaps or lines in the star spectra told us, if sufficiently identified, of the presence of certain elements, the absence of other lines did not, therefore, prove the absence of those elements. We knew the spectrum of oxygen from the laboratory experiments of Schuster and others, who observed bands and bright lines in series of triplets. Some of these groups of bands—e. g., the B group—were seen in the solar spectrum. But we had reason to believe that the B group was due to the terrestrial atmosphere, through which we looked at the sun and stars, and the presence of oxygen in the sun had been doubted (although oxygen had been found in certain stars), until Runge and Paschen brought evidence of solar oxygen. The confirmation of this observation by Runge and Paschen was connected with recent researches on titanium oxide. The spectra of Antarian stars—that is, of stars having spectra similar to that of Antares—were marked by certain flutings of lines on the violet side, and A. Fowler had noticed these flutings in the arc spectrum of titanium oxide, while Duner had discovered the same flutings in the solar spectrum, and Hale had identified some bands in the red portion of the titanium arc spectrum with bands in sun-spots. Within the last two months the same bands had been found at Cambridge in α Orionis.

Astronomy, Mr. Newall continued, had indeed given assistance to chemistry and physics in return for what these sciences had done for astronomy. In the sixties Angström had measured series of hydrogen lines in star spectra. Balmer had studied the numerical relations of those lines, and in 1888 deduced the formula for the wave-length λ of any hydrogen line: $= 3645.6\ \lambda.\ m^2/(m^2-4)$, where m was any integer. But those relations had struck Huggins long before that date, and he had predicted, and found, hydrogen lines corresponding to values of m up to 31; this investigation had afterward been developed by Alexander Herschel, Deslandres, Rydberg, and Kayser and Runge.

The lecturer then turned to the more controversial question as to what stellar evidence could teach us concerning chemical affinity. The problem was related to the classification of stars. We distinguished four chief groups of stars—blue stars, solar stars, and banded spectrum stars of two types, and intermediate groups—and the number of bright stars belonging to these groups had been carefully counted in both hemispheres. In the first group the presence of helium, which was generally associated with oxygen, silicon, calcium, and magnesium, was an important criterion for a subdivision. Lockyer broadly distinguished between stars of rising temperature and stars of falling temperature, basing the distinction on the relative intensities of the lines of certain elements. But if we arranged the helium stars as to the definiteness of their lines, then the magnesium lines gave one order, and the silicon lines gave another; the magnesium lines became brighter as the helium lines faded.

The photosphere might largely be a temperature effect; but to account for the relative intensities of different lines in different spectra, we wanted something more selective in its action than temperature. That cause might be found in electrical forces. Referring to the emission of negative corpuscles (as studied by Richardson and Wilson) by hot platinum—an emission which, as Wehnelt had shown, was increased to an extraordinary degree by the presence of calcium or calcium oxide—and to the attempt of Stark to localize the radiation of bright lines on corpuscular views, Mr. Newall pointed out that the sodium vapor was in different states in different parts of a spirit or gas-flame. We could separate the flame-cone from the sheath and the intermediate zone; and if we looked at a gas-flame in which salt was evaporated through a spirit-flame, then the outer region of the spirit-flame would absorb the sodium light. Gravity and electrical forces might, to a certain extent, oppose one another in star vapors, and complicate the phenomena.

The narrowness of the stellar lines was, Mr. Newall considered, difficult to account for. The atmospheres of the sun and stars must be in an indescribable turmoil; and under such conditions, with strong convection currents we obtained broad, instead of narrow, lines in the laboratory. We could not explain these features. Yet there must be a significance in the coexistence of the lines of helium with silicon, oxygen, calcium, and magnesium; and the chemist who so far regarded helium as an inert element might look for affinities with these elements.

In his second lecture Mr. Newall started from the Doppler principle, which was enunciated by Doppler at Prague in 1842, with special regard to the colored light of double stars. According to this principle, the length of any waves, of sound or light, should apparently be shortened if the source of the waves approached the observer. Thus, if a star moving toward us sent out sodium light, the light would appear to us to be of shorter wave-length than ordinary sodium light, and the sodium lines would thus be displaced toward the violet end of the spectrum, while the lines would be displaced toward the red if the star receded from us. That this principle was correct for acoustical waves was proved by Buys Ballot at Utrecht in 1845; and we all knew that the pitch of the whistle of a locomotive seemed to become higher as the engine came up to the station where we were standing, and lower again when the engine passed away from us. In the years 1866 to 1868 Huggins had directed his refined researches toward the discovery of such displacements in stellar spectroscopy, and thus a new school of stellar spectroscopy had been opened. While up to that time we had been anxious to identify the position of the stellar lines with the lines of the elements as fixed in our laboratory, we had since then chiefly been looking for the slight displacements which told us whether the star was moving up to us or away from us. These observations only gave us information as to any movement in the line of sight, of course, and would not disclose movements across the field. If λ was the wave-length under observation, $d\lambda$ the apparent displacement, v the velocity component of the star in the line of sight, and L the velocity of light, then $d\lambda/\lambda = v/L$. Now L was 300,000 kilometers per second, and we could in this manner determine a value of v equal to 0.6 kilometer; 300 kilometers per second would be the velocity in the line of sight which would give a displacement equal to the space between the two D lines of sodium.

Mr. Newall explained how researches in stellar spectroscopy were conducted at Cambridge—with the telescope which Mr. Newall's father presented to the observatory. The spectroscope, which was attached to the lower end of the telescope, consisted of a train of four prisms, together of 14 inches base length. A comparison photograph of a spectrum was first taken, the spark of a Ruhmkorff coil being made to pass, e. g., between two electrodes of iron or titanium. Then the star spectrum was photographed on the same plate, with an exposure ranging from 5 minutes to an hour or more; immediately afterward the iron spectrum was again taken, sometimes twice, so that the star spectrum was produced between two (or three) iron spectra. The stellar lines would then appear in direct alignment with the iron lines, or a little to the left or right of them; the immediate neighborhood of other lines—for instance, of scandium or titanium—often made the identification difficult, as Mr. Newall pointed out on his photographs. After the photography came the drudgery of reduction. The first element of difficulty was that the earth itself moved, so that apparent deviations varying from —32 (meaning that the star seemed to approach us at the rate of 32 kilometers per second) to +24 (star receding) finally came down to deviations lying between —8.2 and —6.4, showing that the star referred to as an example—namely, α Bootis—was really approaching us at the rate of 6 or 8 kilometers per second in the half year, February to July, 1904, over which this series of observations extended. Only the most reliable observations had been taken into consideration in this calculation; if all the observations of this series had been considered, the fluctuations in the rate would lie between 4 and 8 kilometers per second.

This work had been proceeding, Mr. Newall stated, in Germany, the United States, Russia, and later at Cambridge, for some time when, in 1895, a check had come from Rowland's laboratory in Baltimore, where it was observed that displacements could also be produced by variations in the gaseous pressure of the source of light. Subsequent investigations had, however, established that the displacements due to the pressure variation could only be very small. We could make that assertion, because the conclusions as to stellar movements, based upon the measurement of displacements, were in agreement with other determinations. Thus those displacements yielded us indirectly the value 8.84 seconds for the solar parallax, while the Eros observations, conducted at Greenwich, yielded 8.80 seconds. The orbital velocities of Venus and Mars also checked the displacements.

The Doppler principle had further been applied to the study of the rotation of the sun and of the planets about their axes. In this case the lines appeared inclined, because the equatorial regions would seem to approach us, while the polar regions remained stationary. By ingenious measurements of this kind Keeler had finally proved that the rings of Saturn could not be solid, but must consist of meteorites, for the inner particles rotated at a higher velocity than the outer particles. The sun's day had also been fixed in this manner by Vogel and others. Mr. Newall threw on the screen the solar photographs taken at Cambridge. In these, some of the oxygen lines were displaced, others were not displaced, and these latter were of terrestrial origin, as we might conclude also from observations made on high mountains where the terrestrial lines become dim.

In considering the question of stellar motions, however, we must, as Mr. Newall pointed out, bear in mind that the greater part of the apparent movement of the stars might be due, as William Herschel had recognized, to the movement of our solar system in some particular direction; and, further, we needed many determinations for each star to ascertain whether its movement was not variable. Pickering had first discovered spectroscopic binaries in 1889. He noticed that a calcium line of a star was sometimes simple, sometimes distinctly double, and that these variations repeated themselves in a definite rhythm. If one of the two stars of a binary was moving about the other, we should observe more or less regular variations of approach and recession; α Aurigæ, for instance, gave an almost perfect sine curve, indicating that the bright star described an almost circular orbit about its fellow. Campbell had been amazed to find that the velocities of 11 per cent of all the stars studied were variable. With the aid of diagrams Mr. Newall explained how these variations and vagaries would present themselves to us, under different aspects, according to the point of view of the observer.

There were, moreover, higher systems—ternary and quaternary stars—Mr. Newall stated in concluding his lectures, and this complexity was both pleasing and distressing. For in our search for reliable data we sought for constant velocities of single stars, but we generally learned that we were dealing with systems whose constituents had movements relative to one another, while the whole system had a movement of its own. The account of these complexities certainly impressed upon the audience the drudgery attendant upon certain parts of an astronomer's work, a fact to which Mr. Newall had not made more than a passing allusion.—Engineering.

TRANSMUTATION OF MATTER.

AT a recent convention of the German Electrochemical Society, a group of papers dealing with the subject of radio-activity were read, all of which gave interesting results of experiments in various phases of this phenomenon. One of these was of particular interest, because it seemed to give pretty conclusive evidence of the production of helium by the disintegration of radium. Another gave the results of an investigation to determine whether the apparent change in weight which had been observed was real. This latter paper is of much importance, not because of the results which it gave—in fact, these were negative—but because of the emphasis which it put upon the necessity of avoiding every possible source of error in the study of this new and striking branch of physical science. With the material sealed within a glass vessel, there was an apparent change in weight easily measured in a balance. This seemed at first good evidence of a loss of weight, as the tube became lighter; but the difference in weight was finally found to be caused by the changes in temperature of the tube and its contents, due to the chemical changes going on within it. This increase in temperature, by causing a slight increase in the volume of the tube, decreased its specific gravity, and thus gave rise to the apparent change in weight. When the tube had come to a stable condition and reached its original temperature, the weight was found to be identically what it had been when the tube was sealed up. Thus, it will be seen that all apparent effects may not be real, no matter how carefully the observations were made, and whenever they are in disagreement with our fundamental ideas of physics and chemistry, they should be scrutinized closely and put to every possible test. The new phenomena are puzzling enough, and are changing our ideas of matter rapidly. There is therefore all the more need to be careful.—Electrical Review (N. Y.).

VENOMOUS INSECTS.*

THE DANGEROUS WEAPONS OF SOME CURIOUS CREATURES.

BY RENÉ BACHE.

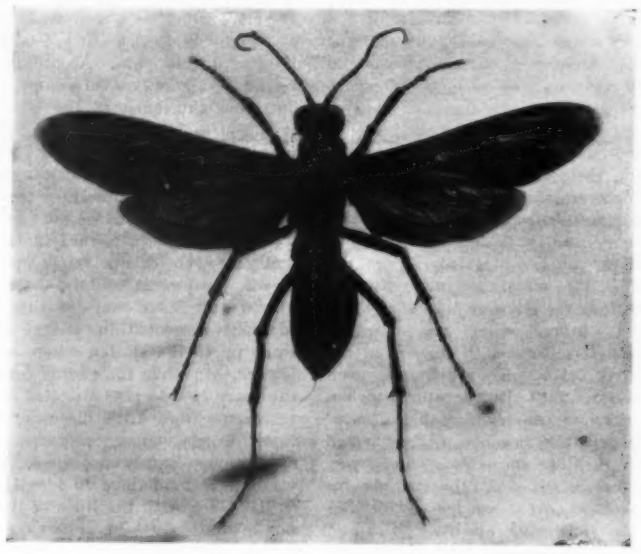
RECENT investigations appear to show that it has been a mistake to suppose that the venom of the cobra was the most deadly animal poison known. It now seems that there are multitudes of existing creatures much more toxic in proportion to their size. It is fortunate, indeed, that they are so small; for certain species of the warrior ants of the tropics, for example, if greatly magnified in size, would be among the most dangerous of living things, because of their extreme ferocity, the severity of their bite, and the extraordinary intensity of the poison with which they are armed.

It is only of late that the poisons carried by insects have been studied, and thus it happens that all existing knowledge on the subject is extremely new. But, when the matter is investigated, it is surprising to find how extensively venom is utilized by animals of this class all over the world. Naturally, it is the large and conspicuous forms whose possession of this weapon chiefly attracts attention; and its formidable character may well excite notice when observation is directed, for instance, to such a creature as the tarantula killer (a species well known all over the southwestern part of the United States), which by its sting is able to paralyze the largest spider as quickly and completely as though an electric shock were administered.

In speaking of the "largest spider," one should realize that these arachnids—commonly called tarantulas in the Southwest, when referring to the great "trap-door" species—occasionally attain a weight of three-quarters of a pound. A specimen of such size would easily cover the largest dinner plate without stretching its legs unduly. There is at least one species in the tropics that catches and devours small birds. And yet the tarantula—which spins no web, but occupies a house built of mud, with a door set on a spring in such a way as to close automatically, showing no sign of the opening—has comparatively little venom.

All spiders are more or less venomous, and one species quite familiar in this country is extremely dangerous. It is commonly known as the black widow, and is occasionally found in outhouses, though ordinarily it lurks under logs and boards. In color it is jet black, with a red spot on the under side of the abdomen. Though its body is hardly bigger than a pea, this arachnid will commonly attack human beings on sight—more especially in the autumn, when, after spinning her cocoon, the female broods over it like a bird over its young, and is very fierce in defense of her eggs.

The typical venomous spider possesses a poison gland and a hollow tube through which the venom is introduced into the wound made by the fang. This gland is situated much as in the rattlesnake, the poison sac being attached to the root of the tooth by a small tube which conducts the venom down through the tooth. Such a similarity of structure between two animals so far apart in the scale of creation as the serpent and the spider, the purpose in both cases being the same—namely, to inject poison—is surely most remarkable.



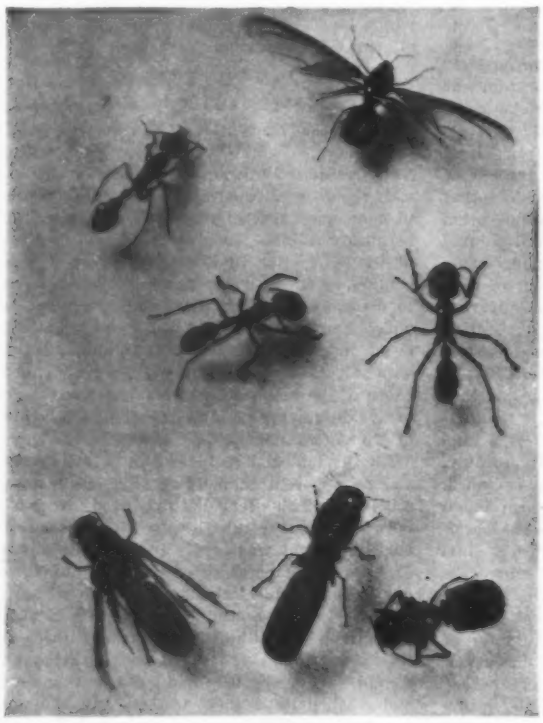
THE TARANTULA KILLER. LIFE SIZE.

Generally speaking, poisonous insects, like snakes, attain much greater size in tropical latitudes, and secrete venom in larger quantities. Thus, whereas most centipedes—a naturalist would say that a centipede is a myriapod, properly speaking, and not an insect strictly; but let that pass—are quite harmless, a few tropical species are exceedingly venomous. In addition, they emit an unpleasant acid vapor from pores along the sides of their bodies, which, if it finds its way into a wound, is very irritating. But the notion, so widely entertained, that their legs are poisonous, leaving a trail as of fire when the creature runs over one's bare skin, is utter nonsense.

There is at least one species of tropical centipede, found in Africa, that is a foot in length—a truly formidable creature—and specimens fully two-thirds that size are frequently fetched to this country from Brazil in logwood. These animals, which are predaceous by habit, devouring snails and small crustaceans, are most commonly to be found beneath dead leaves or other such debris in the woods. In the poisonous members of the tribe the venom gland is at the base of the jaws, which are capable of inflicting a nasty bite. It is suspected, by the way, that some sort of poison apparatus is possessed by the common household myriapod (related to the true centipedes), which, if caught between bed sheets or otherwise cornered, will bite, severe swelling and pain following the injury.

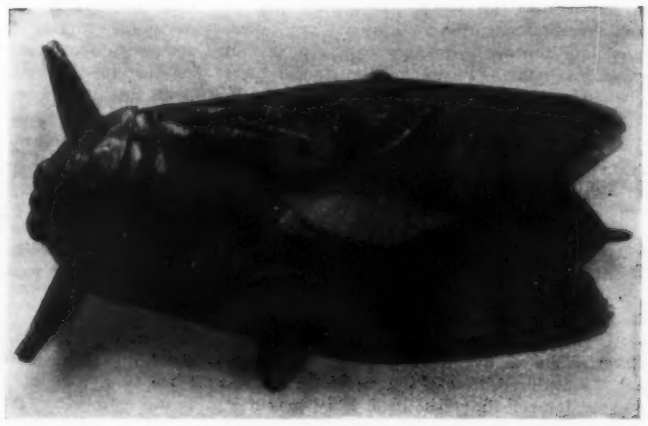
Fatal results have in many recorded instances followed encounters with scorpions, which in warm latitudes sometimes attain extraordinary size—seven or eight inches in length, with powerful claws resembling those of a crab. Recent study of the subject has revealed the fact that the venom of these arachnids is contained in a small gland at the end of the tail, which terminates in a horny and exceedingly sharp point, called the "sting." The animal carries its tail curled over its back, and when it wishes to fight snaps with it over its head, seldom missing what it aims at. When the sting penetrates the skin of the victim the poison is emitted through it by a contraction of the above-mentioned gland.

The scorpion is an extremely vicious creature, and its character is well portrayed by an Oriental myth, which tells how, on a certain occasion, one of these arachnids while on a journey came to the bank of a wide river and paused in perplexity unable to cross



BULLDOG ANT, MALE LEAF-CUTTING ANT, BAD-SMELLING ANT, DRIVER ANT, FEMALE LEAF-CUTTING ANT—ALL VENOMOUS.

A NINE-INCH AFRICAN CENTIPEDE.



ELECTRIC-LIGHT BUG. AN INSECT VAMPIRE SAID TO SUCK THE BLOOD OF FISHES.

VENOMOUS INSECTS.

* From American Homes and Gardens. Published by Munn & Co.

over, yet unwilling to return. A tortoise, seeing his situation and moved by compassion, took him on his back as a passenger, and was swimming toward the opposite shore, when he heard a noise upon his shell, as of something striking him. He called out to know what it was, and the scorpion answered: "It is only the motion of my sting. I know it cannot injure you, but it is a habit which I cannot relinquish." "Indeed!" replied the tortoise. "Then I cannot do better than to free so bad a creature from his evil disposition, and secure the good from his malevolence." Saying which, he dived under the water, and the scorpion was drowned.

In the Tierra Templada of Mexico there is a locality known as the Valley of Scorpions, because of the extraordinary numbers of these creatures found there. It is said to be hardly possible to turn over a stone without discovering three or four wicked-looking specimens beneath. They are not large, as a rule, but are of a pale color and reputed very dangerous—the pale hue, according to popular belief at least, being a bad sign. A pity it is that more is not known about the venom of scorpions, which, it might be mentioned, are often fetched from the tropics to our own seaports in bunches of bananas. Their sting is evidently intended merely as a defensive weapon, and is not employed for killing the insects which they pursue for food.

In temperate latitudes ants, while frequently an annoyance, are never dangerous. Naturally, then, it is difficult for us to realize the perils which occasionally threaten human inhabitants of the tropics when they are obliged to fly for their lives from such insects, which, marching in great armies, are not to be resisted by any known means whatsoever. The so-called "driver" ants of Africa, for example, move in columns sometimes a mile in length, and they turn aside for nothing. If a house happens to be in their path, the inmates have no choice but to vacate the premises, else they would be quickly killed and eaten. Cattle and horses are often destroyed, and even elephants and the largest serpents are assailed, their skeletons, picked perfectly clean, being left behind to mark the route pursued by the ants.

The driver ants are quite large—about an inch in length and thick set. They have very sharp, sickle-shaped jaws, with which they literally bite out pieces of the flesh of a person or animal attacked. At the same time they thrust into the victim a poisonous sting which they carry at the extremity of the abdomen, being "business" at both ends. It is not surprising that, under such circumstances, assailed by hundreds of these formidable insects simultaneously, a human being, or the largest beast, should soon succumb. Indeed, a man, however armed, is absolutely helpless against them. The only good thing claimed in behalf of the drivers is that, when they go through a house, they kill every rat and bug on the premises.

In tropical America there are certain "robber" ants which are equally dangerous by reason of their ferocity, the severity of their bite and the deadly character of the venom they carry. They are vagabonds, occupying no permanent home, but leading a wandering life. Sometimes they move in phalanx formation, a marching army occupying a space of five or six yards, in which the insects are densely massed. While the main body progresses in this compact order, skirmishers are thrown out, and here and there a small column leaves the phalanx to forage. Every living creature that can get out of the way does so. If a man, on a journey through the tropical forest, happens to encounter an army of these ants, he is instantly attacked. They swarm up his legs, drive their pincer-like jaws into his flesh, and sting with their tails. No creatures more ferocious can be imagined.

In the forests of tropical South America are predatory tribes of so-called "bad-smelling" ants, which are accustomed to attack and devour small mammals and insects. They are of exceptionally large size and glossy black; their sting is severe and poisonous, and their bite most unpleasant, their jaws being big and sharp. In glands on the sides of the thorax they secrete an oily fluid, which, emitted as a means of defense when they are captured, diffuses a markedly disagreeable odor.

The famous leaf-cutting ants, which are widely distributed in the tropics, are poisonous, their stings being decidedly severe. They live in colonies underground, and are a good deal of a nuisance, destroying cultivated plants and especially fruit trees. The workers cut out pieces of leaves with their jaws, carry them to their nests, and chew them up to make mushroom beds. When thus engaged, passing over the ground in numbers, they look as if they carried little umbrellas over their heads. The beds prepared in the manner described produce a tiny species of mushroom, which, when it has reached a certain stage of ripeness and succulence, is fed to the young ants. This fungus, by the way, has been cultivated artificially in the laboratory.

In Australia the inhabitants are much afraid of the sting of a certain species of ant, known as the bulldog, which is said to be painful and even dangerous. It is a predaceous insect, found nowhere except in the island continent, and commonly preys on caterpillars and beetles of various kinds. Its bite is quite severe, and with such determination does it hold on that the jaws retain their grip even when the head has been

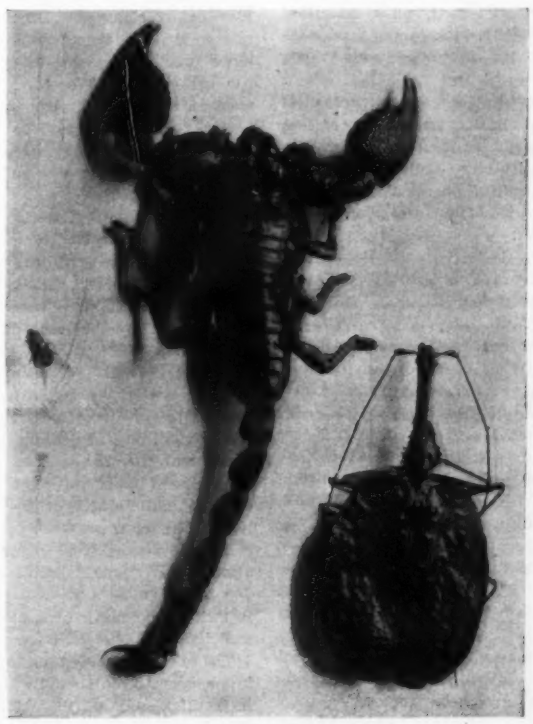
A BIRD-CATCHING SPIDER OF THE TROPICS.—TWO-THIRDS NATURAL SIZE.

pulled from the body—whence the popular name bestowed upon the creature.

A venomous insect that causes not a little unhappiness to human beings in the southwestern part of the United States is popularly known as the "great, big bedbug." The term is pretty accurately descriptive, inasmuch as it is to all intents and purposes a bedbug of exaggerated size, nearly an inch in length, with a flat body, a pointed head, a strong beak, and a "buggy" odor even more offensive than that of the familiar household insect. Worst of all, it has wings, and flies at night, being attracted to open windows by lights. Coming originally from Mexico and Texas, it is making its way steadily eastward and northward, and has already invaded the Mississippi Valley. Apparently, it is merely a question of time when it will invade the East. It passes the winter under the bark of trees or beneath stones, and attacks human beings only in the spring.

Within the last few years there has been much to do over the "kissing bug." It is not a definitely descriptive name, being applied seemingly to a number of different species of insects which inflict more or less venomous bites. The biggest and worst of the kissing bugs, however, is reasonably plentiful in Texas and New Mexico. One of its pleasing habits is to crawl beneath the blanket of a person camping out, or otherwise sleeping in the open air, and to insert its beak into his person, thereupon proceeding to suck until its abdomen is distended to the size of a small hen's egg. This, however, is not the worst of the injury, which is liable to produce a bad sore, difficult to heal.

One of the most remarkable of predaceous insects is the familiar "electric light bug," which eats young fishes. It is a huge fly, and before the introduction of electric lights was supposed even by entomologists to be decidedly rare. It is a diver, and its habit is to plunge into a pond, seize a little fish, and suck its blood. The tarantula killer carries at the end of its tail a sting, which is connected with a poison gland. It pounces upon the spider, paralyzes it with a blow of its weapon, and then drags it to its burrow, where it serves as food for the young of the captor.



A SCORPION (ONE-HALF NATURAL SIZE). ALSO A CURIOUS BUG OF PREY (BEETLE) FROM JAVA.

VENOMOUS INSECTS.

AN IMPROVED LIQUID COMPASS.

A LIQUID compass designed by Capt. E. W. Creak, C.B., R.N., F.R.S., in 1889, has been used since that date in torpedo craft with great success under severe trials; and in other vessels of H.M. navy for auxiliary purposes.

In a compass exhibited by Commander Chetwynd at the Royal Society recently, the important improvements effected are as follows:

The diameter of the card is considerably smaller than that of the bowl, the proportion being three-quarters, so that the edge of the card is substantially outside the influence of that ring of damping fluid which, on altering the ship's course (or by turning the compass bowl), adheres to and is drawn round on the inner surface of the bowl.

The edge of the card being so far from the inner surface of the bowl, on which the lubber's line is usually marked, a special lubber's mark or pointer is introduced projecting horizontally from the bowl on a level with the card. The extremity of this pointer, filed to a fine point and being in close proximity to the edge of the card, obviates all possibility of error of parallax in reading the course, without in any way causing a disturbance of the card.

A magnifying prism is superimposed to magnify the graduation marks of the card to a convenient size for steering or taking bearings. This prism also presents an image of that part of the card required, in a more convenient direction, as regards the helmsman's eye, than that in which ordinary compasses are viewed.

Compasses of this pattern have been exhaustively tried in vessels of H. M. navy with such satisfactory results, particularly as regards freedom from disturbance on alteration of course, under conditions of extreme vibration, shock of gun-fire, and in rough weather, that the Lords Commissioners of the Admiralty have decided that they are to be adopted for standard and steering compasses in all future ships of His Majesty's navy.

THE ARTIFICIAL DISPERSION OF FOG.

THE SOLUTION OF A MUNICIPAL ENGINEERING PROBLEM.

BY M. M. DIBOS.

Fog is a frequent cause of inconvenience and accident in city and country, and it has occasioned more than one fatal railway collision, but it is still more dangerous at sea and is accountable for the majority of shipwrecks. In recent years a means of communication between fog-bound vessels has been afforded by wireless telegraphy, but comparatively few vessels are yet equipped with wireless apparatus.

Let us examine the conditions of formation of fog. If the temperature falls below the dew point, some of the aqueous vapor in the atmosphere immediately condenses in fine drops which remain suspended because of their lightness and the resistance which the air opposes to their fall. These suspended drops of water constitute fogs and mists.

Maritime regions, such as the eastern coast of America, Norway, the British Isles, etc., the shores of which are washed by the warm waters of the Gulf Stream, are frequently covered by fogs and mists, caused by the evaporation of those waters and the condensation of the resulting vapor by contact with the cooler air. The density of such a fog is proportional to the difference of temperature between the air and the sea or the ground.

Aitken has proved that the presence in the air of solid particles is an essential condition of the formation of fog. The air holds in suspension not only mineral dust, but also organic particles in great variety—infusoria, spores of fungi and other cryptogams, pollen grains, etc. In the course of balloon ascensions I have found that as the elevation increases, the dust in the atmosphere diminishes and disappears entirely at great heights, where the sky is perfectly clear and begins to lose its blue color, which is due chiefly to the presence of water vapor. Both mineral and organic dust, however, are found in greater or less quantity at sea, at very great distances from land, from which the dust is probably carried by violent gales and trade winds. Mineral dust from volcanic eruptions is often found in mid ocean at vast distances from its source.

Large cities and manufacturing towns are covered with fogs of great density and peculiar color, while at sea and in the open country even the densest fogs are colorless. London and the cities of the "Black Country" of England are notorious for the presence of thick black fogs. In France, the fogs of Lyons are especially dense and those of Saint Denis and Aubervillers, near Paris, are very thick, dark, and fetid.

In support of Aitken's theory, I give a summary of observations of the fogs of a few large cities. Paris, although it can not be classed strictly as a manufacturing city, burns annually 37 kilogrammes of coal for each square meter of its area (7.6 pounds per square foot).

Hence, according to Prof. Gautier's experiments, the production of soot is about 2 grammes per square meter (2.9 grains per square foot), or 160,000 kilogrammes (about 160 tons) in the entire city. This mass of soot settles and forms a grimy coating on all objects.

Similar deposits formed in London and Manchester have been found to contain:

	Per cent.
Free carbon	41.5
Solid and liquid hydrocarbons	13.1
Various bases	2.1
Sulphuric acid (SO_3)	4.6
Hydrochloric acid (HCl)	1.4
Ammonia in combination	1.4
Iron and magnetic oxide of iron	2.7
Other mineral substances	32.2

The air of Paris contains, in the form of hydrocarbons produced by combustion and soil fermentation, twice as much carbon as is found in country air and one-third more hydrogen, as appears from the accompanying table.

The air of Paris also contains the following combustible gases:

	Parts in 1,000,000 by volume.
Free gaseous hydrogen	194
Formene	121
Hydrocarbons of the aromatic series ($C_n H_{2n+6}$)	17
Carbon monoxide (with traces of hydrocarbons of the series $C_n H_{2n}$ and $C_n H_{2n-2}$)	2

The pollution of the air and the blackening of buildings and monuments are not the worst evils of smoke. Pasteur, Duclaux, Roux, Potain, and others have proved that sunlight is a very active destroyer of microbes, which are killed by the blue, violet and ultra violet rays. Now Tyndall, Gérardin and, in particular, Aitken, have demonstrated that the solid particles of smoke have the singular property of condensing water

	Carbon. Milligrammes in 100 Liters.	Hydrogen. Milligrammes in 100 Liters.	Carbon. Troy Grains in 1 Cubic F. of.	Hydrogen. Troy Grains in 1 Cubic Foot.
Air of Paris	12 29	4.32	0.054	0 019
Air of wooded country	6.12	3.39	0.027	0 015
Air of high mountains	1.19	2.40	0.005	0 0106
Air of the sea	0.02	1.73	0.0008	0 0076

vapor upon themselves and thus forming fogs, which arrest the more refrangible rays, which have the greatest bactericidal power. It has been proved by actinometric measurements that the sun's rays lose from 40 to 50 per cent of their actinic power in the central parts of large English cities and that the light received by the suburbs of these cities is not more than one-third of that which falls at the same season on moderately elevated regions in Switzerland. Depriving large cities of sunlight means depriving them of their most powerful natural means of sanitation. Sir William Ramsay has pointed out the disastrous effects of smoke and the fog which it causes, and English physicians are unanimous in attributing grave diseases, especially tuberculosis, to these agencies.

I assume, then, that the presence of dust or smoke in the atmosphere is almost necessary to the formation of fog. Each solid particle becomes covered with a minute quantity of water. The drops thus formed continue to float in the air, but they are not in stable equilibrium.

Hence it occurred to me that by producing a mechanical shock, a vibration, a wave, in a stratum of fog, it might be possible to precipitate the suspended drops to the ground, and that these drops, in falling, would coalesce with and carry down with them the drops of lower strata in which no such shock had been produced.

Aitken says that if there were no atmospheric dust neither clouds nor fogs would exist, but the excess of water vapor, causing supersaturation, would condense directly on the ground or melt into the sea. There would be dew but no rain. Thus the hydraulic system of the world would be greatly modified.

It is noteworthy that the conversion of storm clouds into rain is brought about by electric discharges between the clouds. This fact suggests a method of the artificial dispersion of fog.

In 1899 I had occasion to test, during a sea voyage of 48 hours, the damaged and repaired engines of a Norwegian steamer. During the first night we ran into a bank of fog of such density that men standing close together on the bridge appeared to each other like silhouettes. We were then about 65 miles northwest of Calais, in calm weather. Standing near a boiler room ventilator, in order to keep warm, we observed that the fog was partially dissipated in front of the mouth of the ventilator, which discharged a stream of hot air.*

By turning the horizontal funnel of the ventilator in various directions we found that the fog was always dispersed within a conical space bounded by the surface of the funnel, prolonged. We then placed in the boiler room a small blower which forced a strong current of hot air through the ventilating pipe and funnel. When the funnel on the bridge was pointed forward the fog was pierced by a tunnel in which objects as far forward as the foremast could be seen. The limit of visibility was 30 meters (about 100 feet). It occurred to me that a longer clear space might be produced by projecting a stream of hot air under pressure. I concluded from my experiments that a conical discharge pipe mounted on the forecastle and discharging hot air under a pressure of 4 kilogrammes per square centimeter (about 57 pounds per square inch, or 4 atmospheres) would produce a clear space ahead from 200 to 250 meters (658 to 820 feet) in length. This is twice the length of a steamer of medium size, and sufficient to avoid collision in many cases.

Then I constructed an apparatus consisting of an inner and an outer cylinder of sheet steel about ¼ inch thick, and of diameters in the ratio of 5 to 6. The inner cylinder contains air under a pressure of 4 kilogrammes per square centimeter (57 pounds per square inch) and is provided with a safety valve set to that pressure and a manometer. The space between the cylinders is filled with steam from the boiler and has a manometer and a safety valve set to 6 kilogrammes per square centimeter (85 pounds per square inch) as the pressure in *ordinary* marine boilers does not exceed 5.5 kilogrammes per square centimeter (78 pounds per square inch). The outer cylinder is covered with a non-conducting jacket and provided with a blow-off cock. The compressed air is discharged through a copper pipe which passes through the top of the outer cylinder and terminates in a horizontal, conical mouthpiece of bronze, 3 inches in diameter. The pipe is pivoted so that the mouth can be turned in any direction. The pressure of the escaping hot air is sufficient to overcome such light winds as accompany fog as well as the relative wind produced by the motion of the vessel, and to extend the fog-dispersing action to a considerable distance—200 meters (656 feet) in my experiments made in 1899, near Boulogne. To the objection that the benefits of this fog disperser are confined to steam vessels it may be answered that it protects sailing vessels by betraying the proximity of steamers. Furthermore it may be operated by steam from the boiler of the hoisting engine which is now a common part of the equipment of sailing vessels and fishing boats.

On reviewing the experiments of Tyndall, Frankland, Rayleigh, Halley, Saussure, Kratzenstein, Faye, Eiffel, etc., and the statements of Kaemtz, confirmed by Aitken's experiments, it appeared to me probable that Hertzian waves, suitably directed, would be more effective that hot air in dispersing fog.

It was necessary to devise special apparatus as the arrangement commonly employed for wireless telegraphy is not suitable for the dispersal of fog. My first apparatus was set up in the winter of 1904 on the roof of a house at Wimereux on the English Channel. An antenna bearing a comb with copper points was maintained at a positive potential of 140,000 volts. The top of the antenna was about 80 feet above the ground, and 180 feet above sea level.

In fog so thick that persons could not be distinguished at a distance of 5 or 6 feet clear spaces from 100 to 120 meters (328 to 394 feet) in diameter were obtained after an average period of emission of 40 minutes. The clear space increased when the faint southerly breeze brought, with the fog, the smoke of Boulogne, 2½ miles away, while with a southwest or west wind, laden with sea fog, the diameter of the clear space did not exceed 100 meters. This seems to show that an admixture of smoke makes fog more sensitive to electric waves and facilitates its dispersion. In the autumn of 1905 I obtained similar results with both static and dynamic sources of electricity.

A priori, a Wimshurst machine appears most appropriate for the production of high potential. Static machines, however, do not work well in damp weather which is precisely the condition in which their highest efficiency is required. Hence dynamo-electric generators, already common on land and on vessels, combined with resonators, furnish more practical means of producing electric waves.

Ashworth has proved that air laden with carbon dioxides, hydrocarbons, exhalations of living organisms or dust is always ionized, and that in air thus contaminated the spark of a static electrical machine is longer than in pure air. Hence it may be inferred that near factories, in cities, over cultivated fields and over certain parts of the sea, the propagation of electric waves is promoted by a pre-existent ionization of the air.

While I was endeavoring to construct a practical fog-dispersing apparatus the distinguished English physicist, Sir Oliver Lodge, had also been attempting to disperse fog by the action of electric waves, and had produced clear spaces from 100 to 110 meters in diameter.

Other things being equal it would appear that intermittent impulses should be more effective than a continuous current. This fact, however, was not manifest at the commencement of the experiments. It is evident that there are atmospheric vagaries which require careful study. I venture to suggest the following plan for the installation of a fog dispersing station. The primary current, produced by accumulators or by a dynamo, traverses the primary circuit of a very large Ruhmkorff coil, giving a spark of about 1 meter. A rotating interrupter and a condenser are intercalated, in parallel, in the primary circuit. The current induced in the secondary circuit is converted from an alternating into an intermittent current by passing through two series of four mercury vapor rectifiers of the Cooper Hewitt type, whence it goes to the inner coatings of two large Leyden jars, of which the outer coatings are connected together. The knob of one jar is connected to earth. From the other (the positive electrode) a wire leads to a crown of points on the top of the antenna mast.

The function of the two series of rectifiers is to maintain constant the direction of the secondary cur-

*A still greater effect must be produced over the smoke pipe, but this would not increase visibility in a horizontal plane. Besides, the fog is simply replaced by equally dense smoke.

rent and yet produce positive and negative discharges. The Leyden jars are successively charged and discharged and the resulting electric oscillations are conducted to the antenna. Lodge's apparatus has no earth connection and the discharges are produced between opposing groups of insulated points.

A clear space of 100 meters would be very useful in harbors, straits, canals, etc., but at sea the desideratum is clearness for 400 meters in every direction from every vessel. On railways even a small clear space around signals would be very valuable. Hence the Northern Railway Company has taken great interest in my experiments, and has installed an experimental apparatus at its Paris terminus. The dispersion can be extended indefinitely by a chain of stations. Antennæ of the netting type spread below signals are also to be recommended. The electric waves employed in dispersing fog do not appear to interfere with the ordinary electric signals.—Abstracted for the SCIENTIFIC AMERICAN SUPPLEMENT from Bulletin des Ingénieurs Civils de France.

METEOROLOGICAL PHENOMENA ON MOUNTAIN SUMMITS.*

BY S. P. FERGUSSON.

MUCH of our knowledge of the upper air has been obtained from observations made on the summits of mountains. With the single notable exception of the Prussian Aeronautical Observatory near Berlin, where, for several years, daily observations at great heights have been obtained with the aid of kites and balloons, we are still dependent upon the mountain observatories for information concerning annual and seasonal changes in the upper air at different heights, and for other data not easily secured except by means of continuous observations made at the same place. The chief error arising from any general application of such observations is caused by the unknown influence of the mountain itself upon the meteorological conditions in its vicinity. The results from observations in the free air do not show the same vertical changes that are observed on mountains, the diurnal periodic change of temperature noticeable on all mountains disappearing at a height of 1,000 meters in the free air.

A few approximate comparisons have already been made, of Ben Nevis (1,343 meters high) in Scotland by Mr. Dines, and of the Brocken (1,100 meters high) in Germany by Dr. Assmann, but in both instances the kite or balloon observations apparently were made at a distance exceeding 90 kilometers from the mountain observatory. Also, Mr. Clayton has compared the temperature on Blue Hill with that of the free air.

The data obtained indicated that the temperature on mountain summits is lower than that of the free air at the same height. No information as to differences of humidity or wind velocity is available, although it appears quite probable that the wind velocity is higher on mountains than in the free air at the same height.

During the last week in August, 1905, I was able to make a comparison of the weather conditions on Mount Washington, N. H., with those of the free air, by means of kites flown in the Ammonoosuc Valley 16 kilometers west of and 1,500 meters lower than the summit of the mountain. This valley is open toward the west, whence come the prevailing winds, and there are ample open spaces suitable for kite flying.

The meteorological data were obtained from four meteorographs constructed as nearly alike as possible in order to secure uniform action, all having the same scales and each recording the temperature, atmospheric pressure, humidity and velocity of the wind upon a paper-covered cylinder rotated once in twelve hours by a clock. The time-scale was about 25 millimeters an hour and data could be obtained every two minutes. Two of these instruments were employed in recording the conditions on the summit of Mount Washington and at the kite station near Twin Mountain, and two were adapted for use in the kite experiments, being a modified form of the kite meteorograph devised by me for use at the Blue Hill Observatory. All the instruments were carefully compared with standards.

The meteorograph on the summit of the mountain was exposed in the north window of the office of the newspaper Among the Clouds, the editor, Mr. Frank H. Burt, very kindly volunteering to keep it in operation during the experiment. The exposure, so far as temperature, humidity, and pressure are concerned, was very good. The anemometer, which recorded electrically, was placed on the roof of the office near the western end and was well exposed to the winds from all directions except those between northeast and southeast, which were obstructed by the other buildings on the summit.

The kites employed were two Eddy kites respectively of 1.67 and 3.20 square meters area, and two "Blue Hill box" kites, each having a lifting surface of 2.0 square meters. A "hand" windlass containing 3,400 meters of No. 11 music wire, and provided with accurate devices for indicating the length of line employed and for recording the pull of the kites, was employed in flying the kites. The heights reached were chiefly determined from altitudes obtained by means of a transit, though intermediate heights could be obtained from the record of atmospheric pressure.

It was intended to keep one of the kite meteorographs as nearly as possible at the same height as the summit of Mount Washington, and the other about half as high, and in this way obtain a vertical section of about 1,500 meters; the Twin Mountain station being 427 meters and the summit 1,916 meters above sea level.

The instruments at the summit and kite stations were compared with a standard thermometer three times each day and comparisons of the kite meteorographs were made at the beginning and end of each flight.

After the apparatus was installed there remained but five days for the actual work of observation, and to my surprise, the wind was so exceedingly light throughout the entire period that but two flights could be obtained; during one of which, however, the upper meteorograph was carried to within 60 meters of the height of Mount Washington. An accident to one of the kites prevented more than one observation at this height; but since this appears to be the first time such observations have been made so near a mountain observatory, it may be worth while giving the results in detail.

AUGUST 24, 1905.

Time, P. M.	Conditions at Kite.				Conditions on Mt. Washington, 1,480 Meters Above Valley.		
	Height Above Valley, in Meters.	Temperature, Deg. C.	Relative Humidity, Per Cent.	Wind Velocity, Meters per Second.	Temperature, Deg. C.	Relative Humidity, Per Cent.	Wind Velocity, Meters per Second.
3:15	0	22.2	90	6	7.2	57	19
3:26	267	19.4	90	6	7.2	57	19
4:11	456	15.6	85	9	6.1	47	20
4:17	648	14.4	100	13	6.1	207	18
4:38	970	11.7	80	14	5.6	25	17
5:02	1,135	11.1	75	12	6.1	28	17
5:31	1,224	11.0	65	11	6.1	30	15
5:41	1,408	10.0	65	13	6.1	30	16
5:43	1,4.8	9.4	65	13	6.1	33	16

At 5:44 P. M. one of the two supporting kites collapsed and the other, not being sufficient to support the meteorograph and line until they were reeled in, fell into the forest on the north slope of the "Three Sugar Loaves" (a small mountain 300 meters higher than the kite station) and the flight came to an abrupt end.

Allowing for the difference of level of 61 meters, the observations indicate a decidedly lower temperature and a much higher wind velocity on Mount Washington than are found in the free air. The hygrometers had not been tested below 40 per cent and the comparison of humidities, while indicating a lower humidity on the mountain, is not considered trustworthy.

Unusually clear, fine weather prevailed throughout the time that could be devoted to the experiments and the summits of the mountains were seldom hidden by clouds. On two successive days (August 25 and 26) the average wind velocity on Mount Washington was less than three meters per second, and on several other days it was almost as low. The conditions for kite flying may not be more difficult near mountains than in other places, but the consequences of accidents to the kites, and the fall of the line and apparatus into the dense forests in these regions, demand that unusual precautions be taken to avoid mishaps. A small gasoline motor for quick manipulation of the line during periods of light wind is almost a necessity.

These experiments have also demonstrated the great value of a simple and compact meteorograph in obtaining data at a place like Mount Washington. The time required for changing the records of the instrument employed was about five minutes, or less, each day, the construction of the recording mechanism of the anemometer being such that this operation could be performed at any time convenient to the observer, or even omitted for a day without loss of records by superimposing. After the meteorograph was installed, on August 20, continuous records of the four elements already referred to were maintained until the close of the season on the summit. It was not practicable to record the direction of the wind on this meteorograph except by means of a device indicating only the eight principal directions; and while such approximate data are useful in studies of climate they are of small value in other meteorological researches.

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THE COLUMN OF TRAJAN.

By COMMENDATORE BONI.

UP till recently it has been believed by archæologists that the column was erected to indicate the height of a hill cut away in order to level the area for the Forum Ulpium, but that view does not seem to accord with the writings of ancient writers. Ancient writers state that three years after the column had been built Trajan left Rome for an expedition and died, and was cremated, and his ashes were collected and placed in a golden urn and buried in a sepulchral column. Looking at the bas-reliefs around the base of the column they seemed to represent the acts of a people after the funeral of a hero. Modern topographists have said that the column could not be sepulchral, as there were no traces of a funeral chamber, but last year my attention was attracted to the loophole window on the southern side of the pedestal, like those admitting light into the spiral staircase, and on examination I found that this had been walled up inside. I noticed also that part of the base, which was decorated with a beautiful wreath of laurels, had been broken away; and on closer examination it appeared as if a violent blow had been given to the top of the base. We know that a bronze statue of Trajan formerly stood at the top of the column, and that in the XVIth century a colossal head of Trajan was found, but which has since disappeared; and the conclusion I arrived at is that in early mediæval times the statue shared the fate of many statues which stood on the summits of the arches, and of other monuments of Rome which were pulled down and taken to Constantinople, or put into the melting-pot and made into church bells or pots and pans.* Following out this hypothesis, I searched the foot of the pedestal to see if I could discover any fragments of the torus. A grotto had been excavated at the base of the column, probably in the Middle Ages, for the purpose of searching for hidden treasure, and on searching I found the missing fragments of the torus. Afterward I penetrated the grotto and discovered a number of human skeletons, the skulls being like those which came out of the Catacombs. From other indications there was no doubt that buildings existed before the column was built. In the eleventh century also a church was built against the column. There is curious documentary evidence of this in the grant of the monks of land to peasants. Having filled up the grotto, I turned my attention to the entrance, and in the inner vestibule at the base of the column found there were still visible traces of a door which had been walled up and plastered over. I removed the plaster and cut away part of the masonry, and found that the door led into a small atrium, turning to the right, where a second door was discovered. This second door led into a chamber, 10 feet long, 5 feet wide, and 6 feet high, which was the funeral chamber. On the outer wall of the chamber were the bricks which closed up the loophole which had first attracted my attention on the outside. Within this chamber were the remains of a funeral-table 2½ feet high and 4 feet wide, and just above the table in the marble wall of the chamber holes had been drilled in such a way as to suggest that clamps going out from the wall had supported on the table two urns, one toward one end and one toward the other end of the table. An inscription still preserved in the Vatican Lapidarium stated that Hadrian had erected a temple *parentibus suis*, in honor of his parents Trajan and Plotina. This temple had stood close to the column, and as it was the custom to erect such temples close to the burying-place of the persons in whose honor they had been erected, the natural conclusion is that the chamber was a sepulchral chamber, and that the table had supported two urns, containing the ashes of Trajan and his wife, the parents of Hadrian. My conclusion is that the main object of the column is plainly that of a sepulchral monument. Now we have to deal with the inscription, the old interpretation of which was that it indicated the height of the hill which by so much labor had been cut and carried away. The inscription read: "AD. DECLARANDVM. QVANTAE. ALTITVDINIS. MONS. ET. LOCVS. TANTIS. OPERIBVS.

SIT. SOKSTVS." And I certainly do not think it confirms the theory of the cutting away of a hill. On making careful trigonometrical calculations of the height of the column I found that it was a *columna centenaria*, exactly 100 feet, so exactly indeed that by means of it the length of the Roman foot could be ascertained with greater precision than had hitherto been reached. Is it possible that any hill should have exactly reached this height? I think it is not, but, further, I feel that, if this was the case, geological evidences of the fact could be found. Ancient authors in their references to the Forum Ulpium have made use of such expressions as seemed to exclude quite decisively the existence of any hill on the spot now occupied by the column. To try and get evidence I made a series of excavations in the vicinity and also across the whole width of the valley occupied by the Forum Ulpium. I found that on the level which would have been formed if the hill had been cut away, there were not the geological strata which in that case would have been laid bare, but remains of early Imperial and Republican works, such as roads, foundations, and drains. Having ascertained that through the whole length of the valley there were no geological strata, I went back to an old hypothesis of mine that the ancient walls of Rome were not of the time of the kings but of the older Republic. In the old maps we found the walls crossing the valley, and an analysis of the materials seemed to prove, to my mind, that the walls were Early Republican. Especially interesting are the unmistakable traces of a wall made of blocks of tufa exactly like those used in the fortifications still extant on the adjoining slopes of the Quirinal, and these are no doubt the remains of the fortifications which we know from Livy to have been built in the fourth century B. C. on the retreat of the Gauls. I think that decisive proof is afforded that long before the column was put up the valley between the Quirinal and the Capitol was practically a level plain with no hill upon it. Further, if any hill ever existed there, it is improbable that the Senate would have commemorated a work done by another people under another Emperor. With this evidence before me, I turn my attention again to the inscription and suggest that it does not, as has been supposed, refer to the altitude of a hill which it had been necessary to remove, but to the height and noble proportions of the buildings that had been erected not only on the level of the Forum Ulpium, but also on the slope of the neighboring hill. It was to afford a view over the Forum and these buildings that the spiral staircase had been constructed [illegible] the column, and standing-place arranged at its summit, where stood the bronze statue of the Emperor.

ELECTRICAL NOTES.

The Westinghouse Electric and Manufacturing Company is now building at its works at East Pittsburg, Pa., 16 electric locomotives for coal mines in West Virginia and Kentucky, one for an iron mine in Sweden, another for a power plant in the State of Washington, and one for a plate glass works at Charleroi, Pa. It is also building complete electric motor equipments for a phosphate mine in Florida and for a lumber camp at Mount Pleasant, Pa., and has in hand an order for 39 motors to drive machinery in the plant of the National Cash Register Company, Dayton, Ohio, and is turning out 59 motors for driving textile mills at East Hampton, Mass.; also a large number of motors for running spindles in worsted mills at Passaic, N. J. The company is further building 15 motors for a paper mill in Canton, N. C., and 20 motors for a paper mill in Fulton, N. Y.

The installation of the hydro-electric smelting plant which the Famatina Development Corporation are laying down at their Santa Florentina mine for the treatment of ore is not of exceptional interest. But the performance of this plant when installed will be watched with interest, for great expectations in the way of economy are placed upon it by the directors. Capt. W. B. McTaggart, chairman of the Famatina Development Corporation, told the shareholders of that company at their annual meeting the other week that contracts for the machinery were let in April, and that the work had been put in hand. The General Electric Company of New York and the Pelton Wheel Company are the contractors for the electrical machinery, and among others who have been intrusted with contracts are Messrs. Adolf Bleichert & Co. and Messrs. Fraser, Chalmers & Co. The cost of the work, including the building of the smelter, the erection of the electrical plant, the pipelaying, and everything necessary to start the smelter going, will be about $2,000,000. The site which the directors have chosen—Santa Florentina—seems a particularly favorable one upon which to erect an electric smelter, for about one mile distant runs the River Amarillo, which the engineers have measured and ascertained that all the year round it is capable of giving a constant supply of power, which by means of turbines will give the power required, sufficient for smelting and a considerable amount available to be carried up to the mines to be used there for electric lighting, hoisting, and other mechanical purposes.

SCIENCE NOTES.

M. Leclerc du Sablou points out (Comptes Rendus) that in France certain varieties of figs are cultivated, the ovules of which are not fertilized, and consequently become aborted, hence the hard, gritty "seeds" present in ripe figs where the ovules have been fertilized, as in Italian varieties, are absent. Figs, where no fertilization has occurred, contain a larger amount of sugar, and are perhaps equally good from every other standpoint, when eaten fresh, as figs where the ovules have been fertilized. In the dried condition, however, the latter are decidedly superior, the pleasant taste and perfume being due to the reserve material in the form of oils present in the "seeds." In addition, when the ovules are fertilized the fig usually weighs more than in the case of unfertilized figs, consequently, a much heavier crop is secured.

The varying depths under London at which the chalk has been tapped in deep wells is shown by some recently-made borings. At Kentish Town (Prince of Wales Road Baths) there was 124 feet of London clay, 46 feet of Woolwich and Oldhaven beds, and 34½ feet of Thanet sands, above the chalk, which was reached at 205½ feet. At the Baltic Exchange, E. C., the chalk was found at 211 feet, there being 112 feet of London clay, 42 feet of Woolwich and Oldhaven beds, and 57 feet of Thanet sands and basement beds. In the Woolwich beds there is included a thickness of 20 feet of "black rock." This, probably, represents the coaly or lignitic layer which is sometimes found in the series. The thickness is, however, unusual. At Upper Clapton (Lea Valley Works), the chalk was met at 120 feet, but across the river, at Camberwell (Warner Road), the chalk had sunk to 163 feet, while eastward therefrom it rose again to 134 feet at Church Street, and to 135 feet in the Old Kent Road. This is in accordance with the well-known rise of the chalk at the inner southeastern corner of London, while at the extreme opposite corner the chalk, already noted at Kentish Town as at 205½ feet, sinks still further at Willesden Junction (Acton Lane) to 340 feet. At the last mentioned place the chalk was pierced, and attained a thickness of 580½ feet, the gault being bored to the extent of 80½ feet, with no intervening upper greensand. The total depth bored was 1,000½ feet, and the well must be considered one of London's deeper wells.—Knowledge.

A very interesting account of Heveas or Seringueiras, that is, rubber-producing plants of Brazil, is given by Dr. Rodriguez in the Boletin del Minist. de Agric., Buenos Ayres. The employment of rubber dates from very early times. It was used by the natives for the fabrication of utensils and for games at the time when Columbus first visited America. Its use in America was introduced by Asiatics, who used rubber during prehistoric times. Each village carefully guarded its acknowledged share of the rubber-producing trees in the forest, valued on account of yielding milk which, when prepared, furnished material elastic and impermeable. For instance, the Mayas and the Nauhas of Mexico not only used rubber themselves, but also bartered this substance with other tribes in considerable quantity. According to the best historians, the towns situated on the Gulf of Mexico paid among other tributes to the Aztecs 16,000 loads of rubber each year. Among the different applications of rubber by the natives may be mentioned the manufacture of balls for the game called pela, played by various tribes in Southern Brazil. The earliest known name given to rubber was Ulé or Hule. The Indian tribe Karaybas, living in Guiana, called the rubber tree Heve, which was adopted by the French botanist Aublet as the botanical name of the genus to which the rubber tree belongs, *Hevea*. The Omanas, a tribe living in the Amazon region, manufactured for domestic uses from rubber tapers, balls, buckets, bottles, vessels for storing beverages, etc. It was through this tribe that the method of preparing rubber and its various uses were obtained by civilized people. Undoubtedly the first rubber known in Europe was brought from the East Indies, and up to 1820 its only use was that of removing pencil marks from paper, hence the name India rubber. This rubber was obtained from a tree called *Ficus elastica* (Roxb.). A portion of the Omanas tribe of Indians migrated to Peru, where they encountered the tree known as *Castilloa elastica*, another rubber-producing plant. To this they gave the name of Cauacho. This word, in a corrupted form, has become the name by which the product of this tree is now universally known. Cauacho became converted into coatchu by the Spanish, and into cautchauc by the French. The first use made of rubber by civilized people is attributed to missionaries living in damp parts of the Brazilian forest, who first covered their shoes with the milk of the rubber tree, and afterward made their shoes entirely of rubber. In 1755 the use of rubber foot gear was established in Para and in Lisbon. Following the historical introduction, the author sketches the gradual development of the economic uses of rubber, geographical distribution of the various plants producing it, collecting and preparing for market, etc.

TRADE NOTES AND FORMULÆ.

Tin Varnish, French.—Alcohol (absolute) 1,000 parts, ruby shellac 200 parts, benzoin 80 parts, oil of lavender 20 parts, Canada balsam 5 parts, to be dissolved with frequent shaking and filtered. If colored with saffron yellow makes an excellent gold varnish for metals.

Paint for Tin Roofs.—30 parts of linseed oil, 10 parts oil of turpentine, 14 parts of English red, and 46 parts of mountain chalk. The coloring substances must be crushed fine and the mixture ground on the color-grinding machine and finally thinned with equal parts of turpentine and linseed oil. The tin must be free from rust.

Preventive of Plant Lice.—Soft soap 40 parts, tobacco extract 70 parts, fusel oil 50 parts, ordinary alcohol 300 parts, water 550 parts. By means of a wooden spatula spread the inside of the neck of a wide-mouthed boiling flask with the soft soap, then add 460 parts of warm water, shaking vigorously until the soap is dissolved; then add the tobacco extract and finally the alcohol, in which the fusel oil has been dissolved; then fill up with water to make 1,000 parts.

Medium for Binding Oil Colors on Zinc.—1 part by weight of chloride of copper and as much salt of ammonia are dissolved in 64 parts of water and 1 part of crude hydrochloric acid added. This fluid, painted on zinc, turns black and dries in 12 to 24 hours; any oil paint will now adhere to the metal. We can also use for such a coating basic acetate of lead. Iron red can be added to a solution of this salt, so that a coat of a very agreeable brown-red effect is obtained. By the addition of other pigments we can obtain lighter and darker and gray colors, also yellowish shades.

Blood Louse Poison.—I. 50 parts of black soap dissolved in 650 parts of warm water; add, when cold, 100 parts of fusel oil and 200 parts of spirits of wine (alcohol); shake, and apply with a brush.

II. According to Göld. (*a*) Sweet milk 60 parts, turpentine dissolved in oil of turpentine 20 parts, sulphide of carbon 20 parts, mixed, to be applied to the root of the tree. (*b*) Sapocarbol 5 parts, water 20 parts.

III. One tablespoonful of green soft soap dissolved in 750 parts (1½ pints) of lukewarm water, mixed with 250 parts (½ pint) of alcohol and 1 tablespoonful of petroleum. To be applied with a brush to the parts of the tree attacked by the insects. It is more practical to spray the tree with this mixture, with the help of an atomizer.

To Make Bonbons.—In a kettle of large capacity, 2,000 parts of coarsely crushed refined sugar is melted with 200 parts water during continuous stirring over an open but even fire, the side walls of the kettle, on which the ascending sugar would be most likely to burn, being best kept clear with the aid of a wet stiff bristle brush. It must be boiled until a sample taken out with the aid of a stick that has become thoroughly saturated by long lying in water, and is not dried off, does not stick, when held between the teeth. The test must be frequently repeated. When the sugar has reached the right condition, the ingredients are added and the mass stirred vigorously until it has become thickly fluid; then it is quickly poured onto an oiled stone slab, folded over quickly two or three times, cut into suitable strips and drawn, without delay, between the oiled rollers. If the mass has then hardened, the different pieces, only connected by a thin film, are separated by shaking in suitable glasses. Rolling machines are not necessary when the bonbons are square. In this case the mass is poured onto an oiled and thoroughly heated metal plate, and before it has become quite hard, separated into pieces by means of roller knives.

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